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Chemical Engineering

MAY 1957

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PRECIPITATION
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CRYSTALLIZATION

Biochemicals Processing

Processing to biochemical purity

Updating heat exchanger costs

How your salary stacks up now

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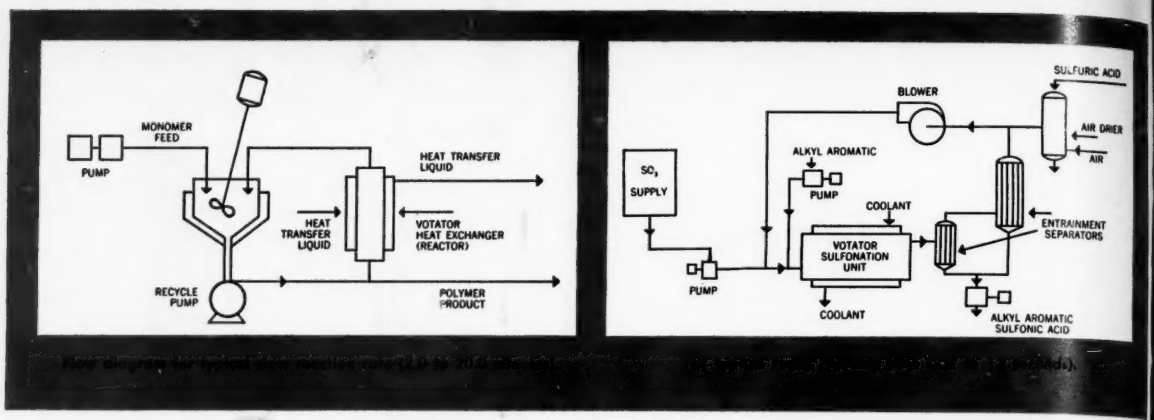

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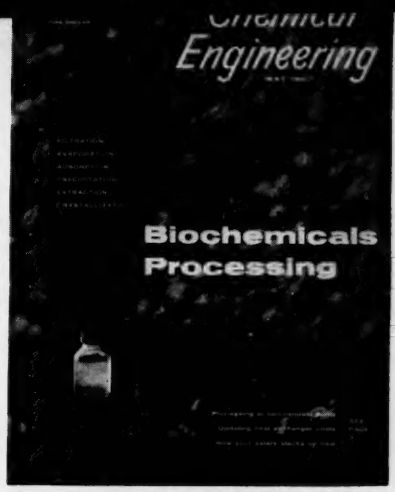

MAY 1957

JOHN R. CALLAHAM, Editor-in-Chief

Today's Process Control

Next month CE will publish its 4th Process Instrumentation issue. This special, 64-page report carries on a tradition started in 1929 when process control was in its cradle.

The 1957 report will help update you on all important areas of this fast-growing field: Present status, recent advances, basic trends, needed improvements, what's coming:

- **Trends**—present and future uses of instrumentation in the chemical process industries.
- **Advances**—six articles on recent advances as well as improvements that're still needed.
- **Elements**—a 24-page tabulation, with sketches, showing details of the basic elements of process control. Some 250 companies have supplied up-to-the-minute information.

Instrumentation "hardware" that will get a close look include analysis instruments, controllers and control elements, data handling (logging, reduction, processing), computer control.

Our 1952 Guide to Process Instrument Elements (in the form of a wall chart) has had constant and heavy demand as a reprint. It has been used as a basic text for many courses in instrumentation.

We've also had requests for permission to translate it into German, French, Japanese, Spanish and Finnish (the Russians don't bother to ask).

We're sure our new 1957 Guide, which we'll reprint as a booklet, will be every bit as popular.

You will get your copy of this Guide, together with the special report, in CE's June issue.

GUIDED TOUR

The chemical engineer as a specialist in separation operations

Next time you get a shot of penicillin, give a thought and thanks to brother chemical engineers. Their job of digging salable biochemicals out of broths and gunks typifies our profession at its best. See how skill and ingenuity lick the problems of complexity and low concentration. (p. 237)

Now, details on uranium process

Just revealed—details of a resin-in-pulp ion exchange process. Pictures and flowsheet give as much as can be told of Anaconda's new way to get a concentrated uranium oxide. (p. 228)

Longer life for automated equipment

Almost overnight, maintenance has jumped to a major spot in management and

Chemical

GUIDED TOUR

engineering thinking. Increased mechanization did it. Our experts will help you keep your equipment up to par. (p. 253)

Updating heat exchanger costs

Better accuracy in estimating heat-exchanger costs will come from our up-to-date information. New tables take into account the significant changes in steel and steel alloy prices. (p. 257)

A new group for your flow file

Starting this month the CE Flow File switches formulas from water to liquids in general. Here are the next four in this popular and clippable CE series of engineering formulas. (p. 274)

How your salary compares

New data on the incomes of 107,832 engineers let you see just how you stack up. Check how well you are doing as compared with your classmates, your contemporaries and other engineers. (p. 313)

To keep pace with development, design, production and technical management in the chemical process industries, more engineers subscribe to CE than to any other magazine in the field. Paid circulation of this issue:

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Chemical Engineering (with Chemical & Metallurgical Engineering) is published monthly with an additional issue in Mid-September by McGraw-Hill Publishing Company, Inc., James H. McGraw (1860-1948), Founder. Publication Office: 99-129 North Broadway, Albany 1, N. Y. See panel below for directions regarding subscriptions or change of address.

Executive, Editorial, Circulation and Advertising Offices: 330 West 42nd St., New York 36, N. Y. Donald C. McGraw, President; Joseph A. Gerardi, Executive Vice President and Treasurer; John J. Cooke, Secretary; Nelson Bond, Executive Vice President, Publications Division; Ralph B. Smith, Vice President and Editorial Director; Joseph H. Allen, Vice President and Director of Advertising Sales; A. R. Venezian, Vice President and Circulation Coordinator.

Subscription rate in U. S. and possessions for individuals in the field of the publication $3 per year (Canada $4), single copies $1. **Position and company connection must be indicated on subscription orders. Send to address** shown in box below.

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Chemical Engineering

Developments

MAY 1957

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XUM

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Condulet* motor controls
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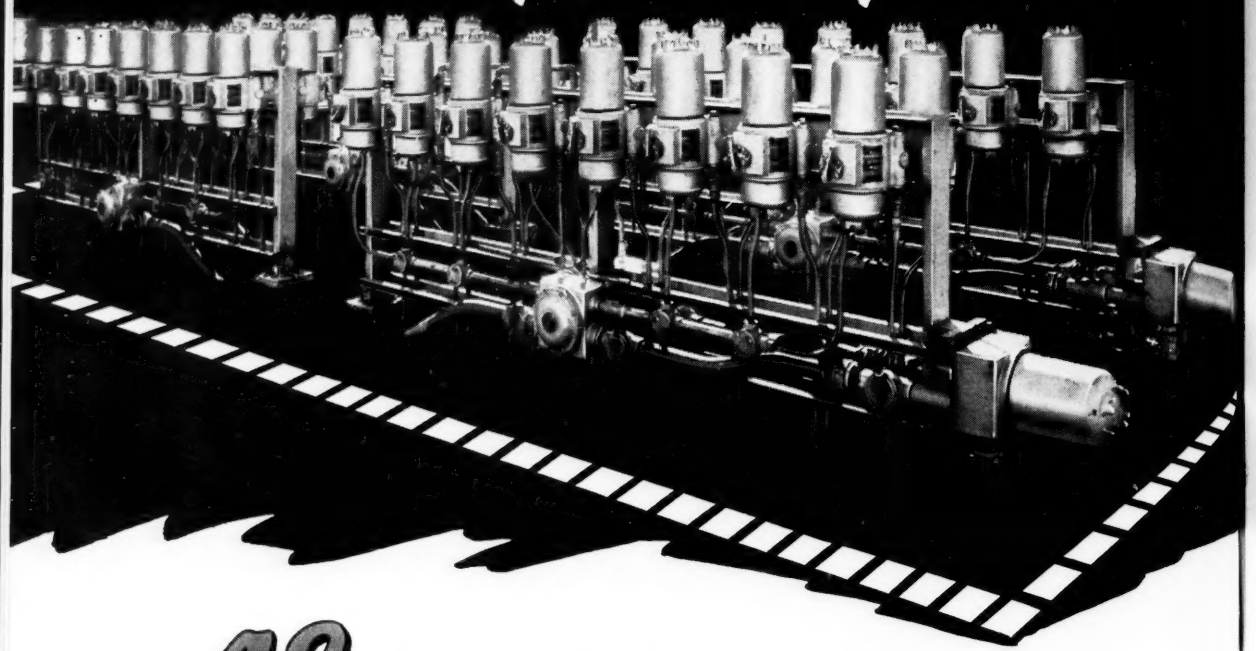

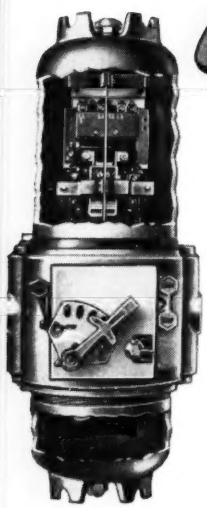

48 Explosion-Proof Combination Motor Starters and Circuit Breakers . . . *in a 25 ft. x 6 ft. Area!*

Crouse-Hinds Condulet* Type EPC Motor Starters and Circuit Breakers are explosion-proof, dust-tight (dust-ignition-proof) and weather-resistant (raintight).

Lightweight cast aluminum construction for easy installation without use of lifting equipment.

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In the installation shown above, 48 Crouse-Hinds Condulet* Type EPC combination motor starters and circuit breakers are compactly arranged in four racks.

If necessary, the 25 ft. x 6 ft. area used could have been cut in half by installing the Condulet motor controls in two tiers. Or, *twice* as many Condulet controls could have been installed in the same area, if required.

The *vertical design* of Crouse-Hinds motor starters, circuit breakers and combinations allows them to be installed only ¼" apart. This compactness produces savings in the construction of steel mounting racks, and in the use of premium floor space.

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DEVELOPMENTS . . .

MAY 1957

Chementator

C. H. CHILTON

√ **American Cyanamid has quietly started up a fluid-bed phthalic anhydride unit at Bridgeville, achieving "substantial economies and improved efficiencies."**

√ **New processes for making carbon black will be explored in pilot-plant facilities being put up by Thermatomic Carbon at Sterlington, La.**

√ **Pyroceram, a new glass-like material, will be announced this month by Corning. It's said to have especially good electrical properties.**

√ **Wah Chang Corp. is piloting a new way to separate tantalum from columbium, reportedly simpler than liquid-liquid extraction.**

Two uranium leaches better than one

Macafee & Co., Los Angeles consulting engineering firm, has come up with a new uranium process asserted to have "substantial" cost advantages—both in plant investment and in operation—over currently used processes, with equal or better extraction.

Process uses a two-step combination of carbonate and acid leaching. First step is to solubilize uranium minerals by "soda oxidation." This involves agitating ground ore in an aerated hot, weak solution of sodium carbonate-bicarbonate for 2 hr., with the addition of carbon dioxide to reduce excess alkalinity. Some uranium is dissolved in this step, but principal action is oxidation and carbonation of refractory uranium minerals, rendering them subsequently soluble in a 4-hr. weak sulfuric acid leach.

Iron, alumina and silica are removed by precipitation; uranium is then precipitated with caustic soda as sodium diuranate.

Cost advantages are attributed to:

- Shorter total treatment time.
- Less expensive equipment because of mild corrosive conditions.
- Lower chemical consumption because of weaker reagent concentrations.
- No major heating requirements.

Macafee has demonstrated the new process in a 50-ton/day pilot plant, achieving recoveries of 96% or better. The firm has applied for patents, is now looking for design and construction contracts.

Is nylon-6 a poor commercial risk?

Two rayon producers who recently began making caprolactam-based nylon as a hedge against waning rayon markets found tough going last year.

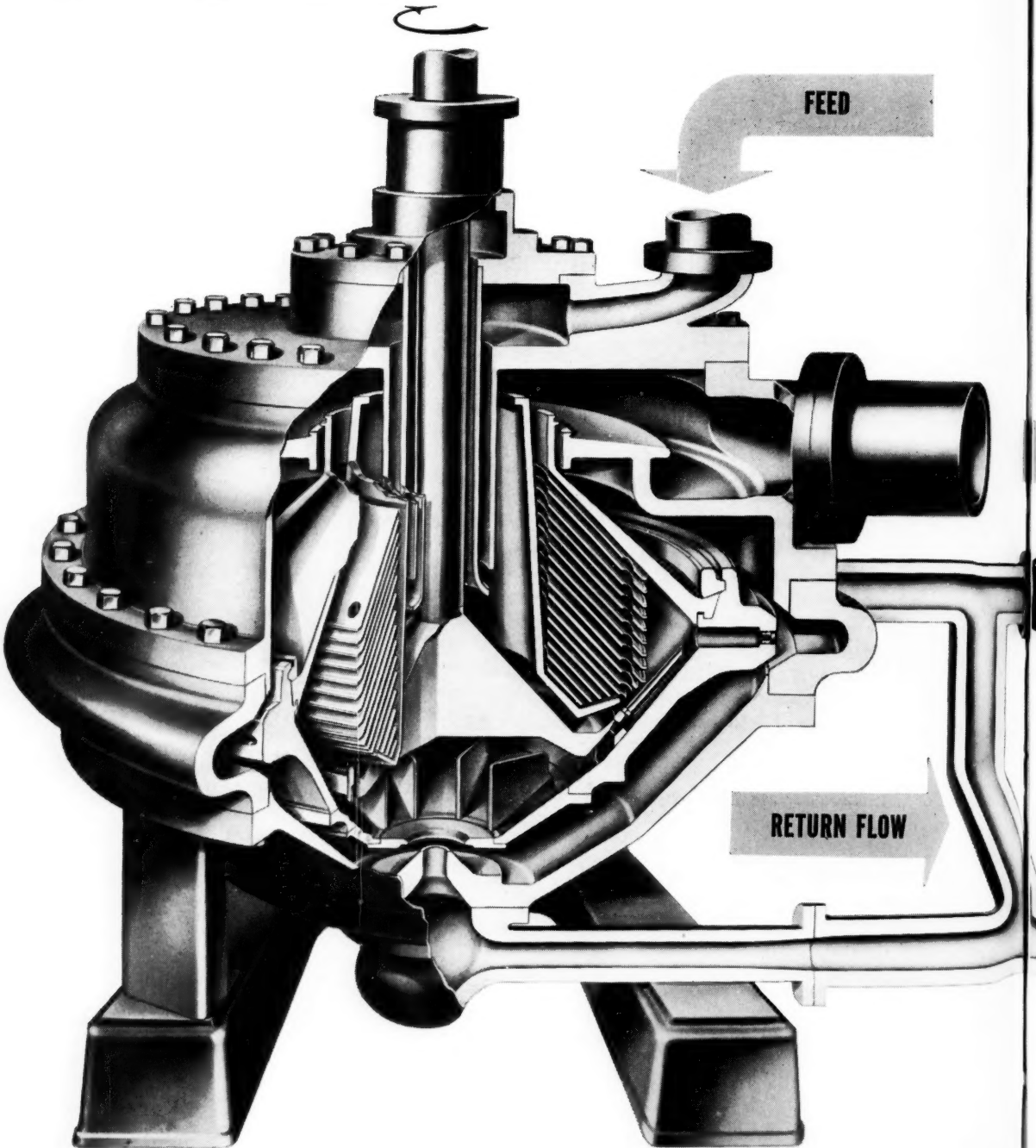
Industrial Rayon's nylon-6 plant at Covington, Va., continued in the red all during

(Continued on page 144)

NOW

Centrifugal Separations

new Merco



under pressure conditions with the

Pressure Centrifuge

Illustrative drawing of Merco Pressure Centrifuge. In this example, wash is being introduced into recycle line at point B. If no wash is required, valve at B is closed. Concentrate is withdrawn at point A.

Newest development in wet processing equipment, the Merco Pressure Centrifuge is designed for all continuous centrifuging applications at pressures up to 110 psi. Key to pressure operation is a specially designed housing closure that has been exhaustively tested at pressures two to three times the guaranteed figure of 110 psi. Equally important, this new unit incorporates the unique Merco "Return Flow" principle for maximum operating flexibility. Under centrifugal forces thousands of times higher than gravity, even the smallest particles in the feed "sink" rapidly outward and are continuously expelled through fixed open nozzles in the rotor. A controlled portion is withdrawn as finished concentrate and the remainder becomes a return flow to the rotor. Wash, if desired, is introduced to the return flow line . . . clear, excess liquor overflows out the top of the unit.

If there's a step in your flowsheet involving concentration, washing, clarification, soluble recovery, or classification *under pressure*, there is a good chance that this new tool will prove useful. Bulletin No. 2600, just off the press, describes the Merco Pressure Centrifuge in detail. For your copy, write Dorr-Oliver Incorporated, Stamford, Conn.

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Check these positive advantages

Pressure Operation — Concentration, washing, clarification, soluble recovery or classification can be carried out under pressure.

No Solids Build-up — All solids entering the unit are continuously discharged. Return flow flushes solid material at periphery of rotor.

No Nozzle Clogging — Return flow principle permits nozzle flow 2 to 10 times as great as the underflow actually withdrawn. Merco nozzles will discharge particles as large as 1/32 inch.

Practical Design — All separating conditions are controlled externally. The unit is equipped with a sturdy housing which has been X-rayed and hydrostatically tested.

1956. American Enka did slightly better, reaching a profitable rate of nylon operations at Enka, N. C., in the fourth quarter. Both plants started up during 1954.

In view of Du Pont's whopping commercial success with nylon-66 (now enjoyed also by Chemstrand), it looks like Industrial and Enka may be backing the wrong polymer. Enka admits that it has produced experimental quantities of nylon-66 and is now studying pros and cons of its commercial manufacture. Industrial Rayon, meanwhile, is evaluating other fiber-forming polymers.

Most intensive area of rayon-nylon competition today is the tire cord field. Although 82% of all tire cord made last year was rayon, Du Pont, who introduced high-tenacity rayon yarns almost 25 years ago, is convinced that "the tire of tomorrow will be nylon."

Recent Du Pont moves underscore its enviable multiproduct position in the synthetic fiber industry. The company will soon be prepared to cut production—if and when economic conditions so dictate—at its Richmond rayon plant and its Waynesboro (Va.) acetate plant. A nylon production unit is going in at Richmond and an Orlon acrylic fiber unit at Waynesboro. Two years ago the company shut down rayon production at Buffalo—pioneer plant of the Du Pont Fibersilk Co.—after 34 years. However, cellophane has kept the Buffalo plant alive. Only Du Pont rayon plant left unprotected at present is Old Hickory, Tenn.

American Viscose, now well established in nylon and Acrilan acrylic fiber through partly owned Chemstrand, shut down its rayon operations at Marcus Hook, Pa., in 1954, although it still maintains major research facilities there and sizable rayon and acetate production at other locations.

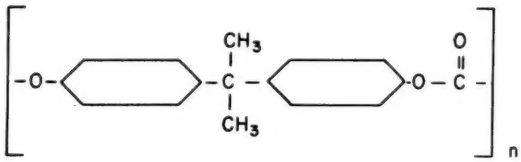
Cheaper way to ship phosphorus

Construction will start next month on private industry's first calcium metaphosphate plant. The $13.5-million installation near Georgetown, Ida., will be operated by Central Farmers Fertilizer Co.

TVA has made cal meta in "demonstration plants" at Wilson Dam, Ala., for some 20 years (*Chem. Eng.*, June 1951, pp. 135-137). Product has higher P_2O_5 content than concentrated superphosphate (62-65% vs. 48%) and is a lot easier to handle than elemental phosphorus. These attributes make cal meta economically attractive as a phosphorus bearer for shipment from Idaho to fertilizer mixers in the corn-belt area. It can be ammoniated to give a high-analysis, granular mixed fertilizer.

Manufacture of calcium metaphosphate involves production of elemental phosphorus, which is then burned to P_2O_5 in the presence of finely ground rock phosphate. These materials react rapidly to give $Ca(PO_3)_2$.

The new plant will include a 35,000-kva. phosphorus furnace and will turn out up to 120,000 tons/yr. of cal meta.



Polycarbonates: New plastics prodigy

This structural formula typifies an exciting new family of thermoplastic resins—the polycarbonates.

Developed independently and almost simultaneously by General Electric at Pittsfield, Mass., and Bayer at Uerdingen, Germany, the polycarbonates offer a combination of toughness, impact strength, heat resistance and dimensional stability unusual for a thermoplastic resin.

Calling its new product Lexan, GE is now turning out small lots for in-company evaluation as molding compound, extrusion compound, film, varnish and coating. When pilot production is established, GE expects to put Lexan on the market at something like $2.50/lb. Volume production, GE hopes, will eventually bring price level down to 50¢/lb.

At 140 C. and 260 psi., Lexan's heat distortion is much less than that of nylon, polystyrene and the acrylics, even less than that of the thermosetting phenolics. Its impact resistance, GE says, exceeds that of all these resins, and cellulosics as well. It also has good electrical characteristics.

Neither GE nor Bayer is ready to disclose specific information about polycarbonate chemistry or production routes. Starting reactants might be a polyphenol and an acid chloride (e.g., phosgene, methallyl chloride).

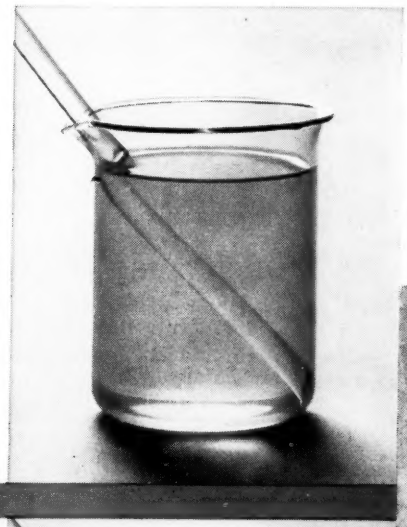
(Continued on page 146)

WHICH sodium silicate suits your process best?

Opalescent Solutions

Baumé	Wt. Ratio (Na_2O to SiO_2)
38° Pearl	1:3.25
40° Regular	1:3.25
41° Acme	1:3.25
42.5° Ajax	1:3.25
47° Ideal	1:2.84
52°	1:2.40
60°	1:2.00

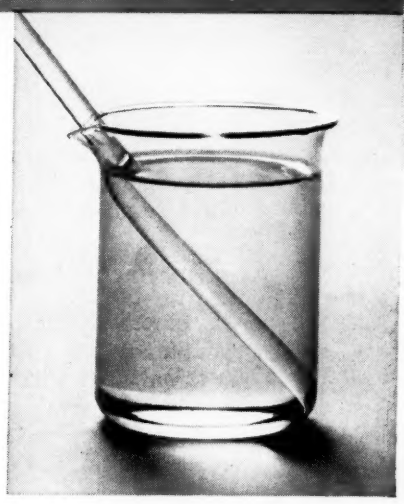
And other ranges of Baumés



Clear Solutions

Baumé	Wt. Ratio (Na_2O to SiO_2)
38° Crown	1:3.25
38° Gem	1:2.54
40° Peak	1:3.22
41° Water White	1:3.25
42° Silk	1:2.54
42.5° Water White	1:3.25
44° Perox	1:1.80
52° Zenith	1:2.40

And other ranges of Baumés



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XUM

One of several production techniques disclosed by Bayer involves emulsion of a polyphenol in a methylene chloride carrier, addition of caustic solution and phosgene plus a quaternary ammonium hydroxide catalyst.

A wide variety of possible polyphenols portends a potentially large number of polycarbonate variations. Bayer and GE each admit to having already synthesized from 20 to 50 different polycarbonates.

New methanol process looking better

Operating difficulties which have plagued the Monsanto-Heyden methanol plant at Texas City since its startup in October 1955 seem to be well on the way to solution.

Plant is now producing and shipping specification-grade methanol. However, Monsanto engineers, as well as those of M. W. Kellogg Co., who designed and built the plant, are still working on process improvements in order to achieve sustained capacity output.

Problems are associated chiefly with preparation of synthesis gas. Plant uses as its synthesis gas feedstock the offgas from Monsanto's acetylene-from-natural-gas unit, already rich in hydrogen and carbon monoxide. Incomplete removal of hazardous acetylenic compounds from this gas stream via steam reforming may account for the troubles at Texas City.

Meanwhile, Foster Wheeler is engineering a methanol plant for Rohm & Haas at Houston which will also use offgas from an acetylene plant (now under construction) for a portion of its feedstock.

Rohm & Haas, while not revealing its process scheme either, confidently expects to avoid Monsanto's troubles. Best bet: Acetylene offgas will supplement natural gas as feed to a partial oxidation synthesis gas unit. This would effectively burn up any potentially troublesome acetylenic compounds.

Coal slurry pumping runs into snags

Pittsburgh Consolidation Coal Co.'s reluctance to publish engineering details of its 108-mi. coal slurry pipeline until its performance was well established now appears to have been a wise stand.

While engineers of contractor Ford, Bacon & Davis and customer Cleveland Electric Illuminating Co. were describing the pipeline as a *fait accompli* at recent technical conferences, Pitt-Consol's engineers were in the Ohio woods—literally—locating and removing a blockage in the line which occurred during startup tests.

Principal reason for stoppage, says Pitt-Consol's James Hyslop, has now been pinned down as improper particle size distribution used in the first test. This was partly due to a mechanical failure in the screening equipment.

Clearing of the plug will permit resumption of test pumping, but no schedule has been set for completion of the tests or beginning of normal operation.

By default, then, American Gilsonite Co. stands a good chance of becoming first successful operator of a long-distance slurry pipeline. Its 71-mi. line from its Bonanza, Utah, mine to its near-completed refinery at Grand Junction, Colo., has already been tested, with full-scale transport of gilsonite slurry expected this month (see *Chem. Eng.*, Sept. 1956, pp. 134-138).

Pumping of gilsonite slurry, moreover, should pose less severe operating problems. Its specific gravity is about 1.05, compared with bituminous coal's 1.25-1.45.

Sulfur burner runs on bed of hot sand

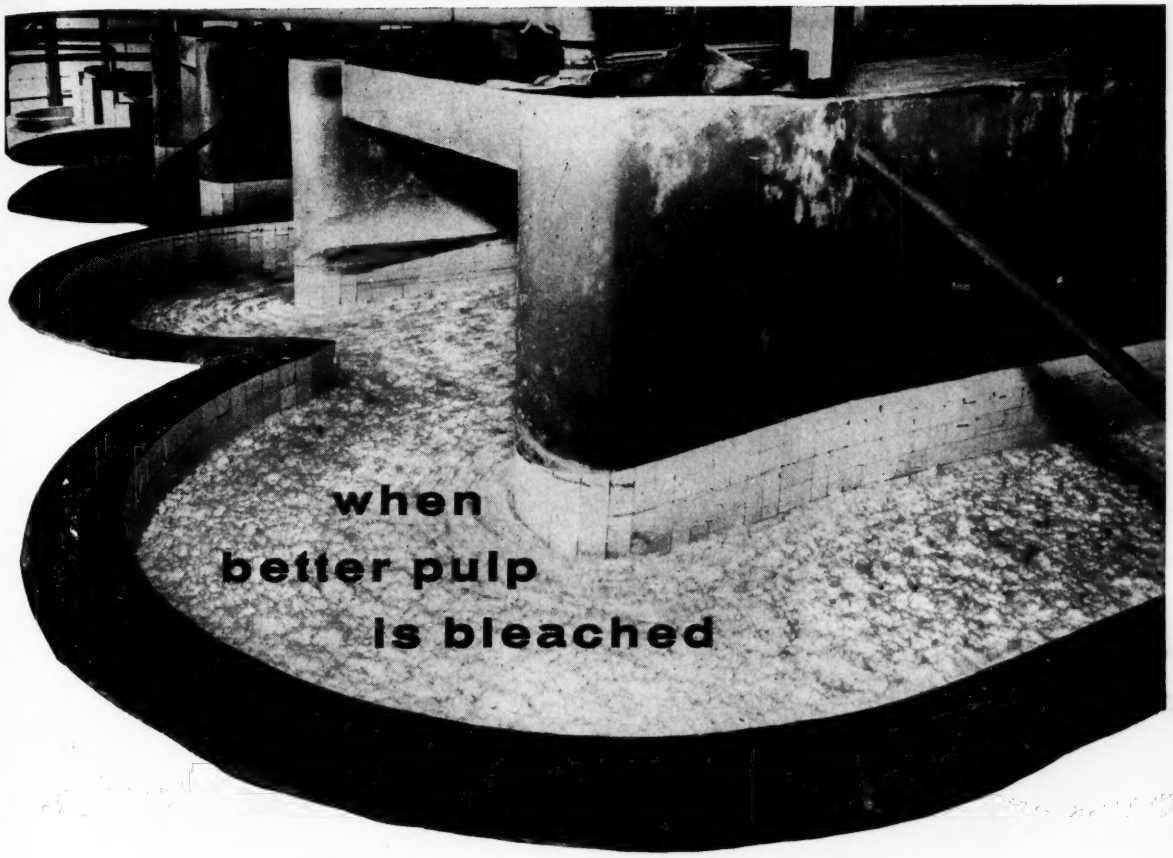
What's the best way to burn a bitumen-containing, 95% sulfur ore?

Compared with high-purity Frasch sulfur, it's tougher to handle in conventional brimstone burners. Yet, unlike lower-grade ores or pyrites, it doesn't contain enough non-sulfur materials to provide a bed in a fluidized-solids burner.

One solution to the problem—operating on a 30-ton/day scale in Australia—is to provide an inert fluidized bed of sand. Commonwealth Fertilizers & Chemicals (Melbourne) reports that its unit has proved to be efficient and economical. Moreover, it responds rapidly to changes in SO_2 demand, doesn't leave a molten sulfur pool to keep burning if the acid plant is shut down.

Unit consists of a 4-ft.-dia. fluid-bed section and an 18-ft.-dia. combustion chamber above it. Sulfur feeds onto the sand bed. Enough air passes through the bed to fluidize it and burn 10% of the sulfur. Remaining sulfur vaporizes, passes to the combustion chamber, there burns with additional air.

For more on DEVELOPMENTS.....148



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DEVELOPMENTS . . .

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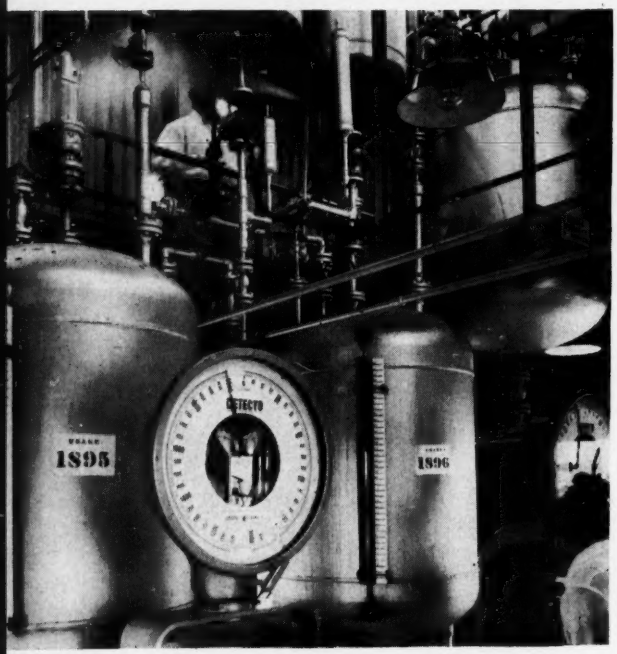

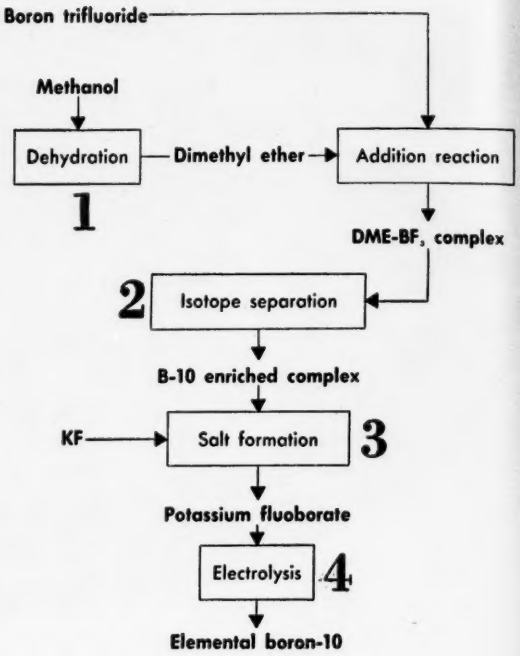

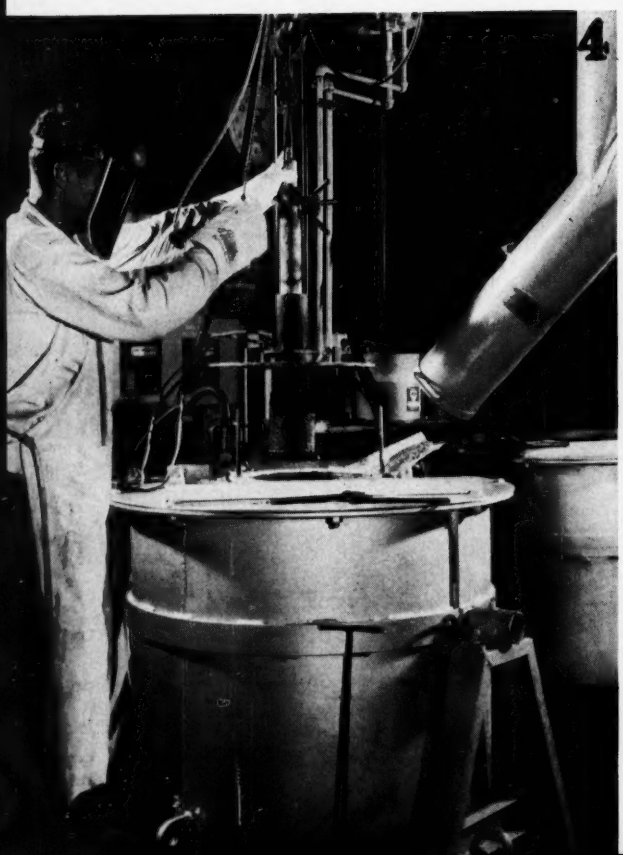

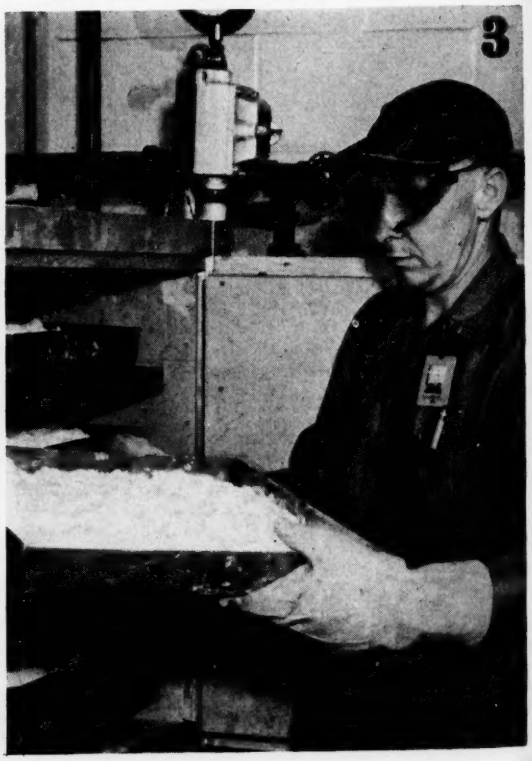

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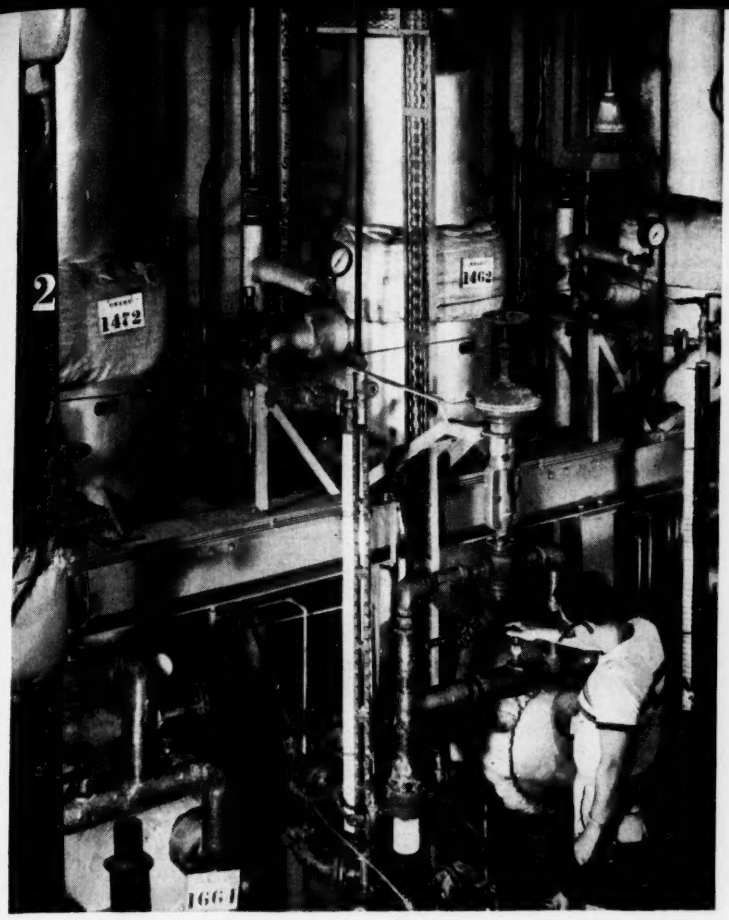

PACKED TOWERS—six of them —provide an estimated 360 transfer units in 350 ft. of total height to fractionate natural boron into its isotopes.

Complex Distillation Separates Isotopes

AEC-Hooker fractionates volatile organo-boron compound to get product enriched in B-10 isotope, converts it to elemental B-10 worth some $1,500/lb.

Using a six-tower distillation train believed to be the world's most efficient fractionation system, Hooker Electrochemical Co., as contract operator for the Atomic Energy Commission, is turning out 3 lb./day of elemental boron-10 in a $4-million plant near Niagara Falls, N. Y.

Separation of B-10 from its isotopic twin, B-11, occurs when natural boron (containing 19.6% B-10) is fed to the distillation train in the form of a dimethyl ether-boron trifluoride complex. Enriched complex from the stills is converted to elemental boron-10 via electrolysis of potassium fluoborate in a fused-salt bath.

AEC's announcement in February that B-10 was commercially available marked the lifting of a tight security lid under which the plant had been operating since its startup in June 1954. Located inside the former powerhouse building of the defunct Lake Ontario Ordnance Works at Model City, the Hooker-AEC installation had been a puzzle to local residents, many of whom thought the plant was processing uranium.

▶Precious Little — While the output from 24 hours' operation can be packed in a 1-gal. paint can, it's worth more than its weight in gold.

AEC's price schedule realistically reflects actual costs involved in producing the isotope from commercial BF_3. At an enrichment of 92% B-10, current price for the element is $3.30/gram ($1,500/lb.) of B-10 content. Thus the plant's output of about 1,000 lb./yr. carries a value on AEC's books of some $1½ million.

Boron figures prominently in the nuclear energy program as a good neutron absorber. Natural boron, in various physical and chemical forms, is used for reactor control rods.

Availability of boron-10 isotope, a superior neutron stopper, may lead to new design concepts in reactor shielding as well as control. Other potential uses of B-10 lie in the field of instrumentation (*see p.* 176).

▶Making Dimethyl Ether — Hooker needed a supply of dimethyl ether in order to form the distillable liquid boron complex. With no large-scale source

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available, the Singmaster and Breyer engineers who designed the plant had to set up their own DME unit, capable of turning out some 40,000 lb./mo.

DME process involves vapor-phase dehydration of two molecules of methanol at 375 C. and 200 psi. over on aluminosilicate catalyst.

Methanol is vaporized with steam, then superheated via electric resistance heaters. Reaction takes place in a single 7-ft.-deep catalyst bed contained in a piece of 4-in. pipe. DME, which has a normal boiling point of −25 C., is purified by batch distillation under pressure.

▶**Simple Complex**—Forming the DME-BF_3 complex requires only simple pipeline mixing of the two chemicals followed by condensation at a slight positive pressure. Condensate, which purposely contains excess DME, is stripped of this excess by subjecting it to vacuum.

Source of vacuum is a Nash pump sealed with white mineral oil. Customary water seal could be a potential source of trouble if water should get into the boron complex. (The same vacuum scheme is used, and for the same reason, with the fractionation towers.)

Boron trifluoride comes into the plant in trailer-mounted compressed-gas cylinders at about 1,200 psi. Unable to buy a commercial reducing valve for precise throttling down to 40 psi., Hooker engineers successfully modified a standard design by substituting Monel and Teflon internal parts.

▶**Isotope Separation**—Although the B-10 and B-11 complexes are separated by fractional distillation, the process does not depend on simple difference in volatility. If it did, B-10 would come off overhead and B-11 at the bottom. In practice, it's the other way around.

Postulated mechanism visualizes the repeated dissociation of the complex in the vapor phase and recombination as liquid phase, with equilibrium slightly favoring dissociation of complex containing B-11 and recombination of complex containing B-10.

For practical design and operating purposes, however, the volatility concept serves admirably. Equilibrium measurements indicate an apparent relative volatility of 1.015, with B-11 complex considered the more volatile component.

▶**Now We Are Six**—The six fractionation towers are hooked up to work as a single unit. Bottom stream from No. 1 column is pumped to the top of No. 2 column, and so down the line. Overhead stream from No. 6 column is fed to the bottom of No. 5 column, and so up the line countercurrent to the downflow.

Columns 1 through 5 are each 18 in. I.D. and 65 ft. high. No. 6 column, 6 in. I.D. and 25 ft. high, was added to original plant to get more capacity. Columns are of Monel and use ¼ × ¼-in. Cannon protruded Monel packing. Hooker estimates that the total system provides 360 theoretical transfer units.

▶**Operating Conditions**—Isotope separation takes place at top-column pressures of 6 in. Hg abs. and temperatures of 91 C. Operation at reduced pressure and temperature minimizes the rate of irreversible thermal decomposition of the boron complex.

By condensing the overhead from each column and feeding it as liquid to the bottom of the next column, Hooker can apply vacuum at six points in the train and thereby avoid an excessive cumulative pressure drop and temperature rise through the train. Bottom pressure in columns 1 through 5 is 12 in. Hg; corresponding temperature is 105 C.

This modus operandi, of course, consumes a lot of steam, especially since reflux ratio at No. 1 overhead takeoff is 75 to 1. Steam consumption is about 2,500 lb./hr., to produce about 2 lb./hr. of enriched complex.

Feed enters the system about one-third the way up No. 1 column. No. 1 overhead (now wasted) contains 12% B-10 (on total B). Bottoms from No. 6 is enriched to 92-93% B-10. This stream is redistilled in a small batch column to get rid of accumulated low-volatiles.

▶**Operating Control**—Primary column control relies on regulation of steam flow to the reboilers. Boilup rate is monitored by measuring pressure drop across each column. Precise transfer rates of liquids between columns is achieved with Lapp Pulsafeeders.

Control problems are unusual because of the large ratio of system holdup to throughput and attendant time lag. Strip-type recorders run at slow speeds so that a 36-hr. record is readily visible on each instrument.

From a cold, empty start, equilibrium is reached only after two to three months' operation. From a scheduled maintenance shutdown, however, plant operation can reach steady state again in about 24 hr.

▶**Elemental B-10**—Enriched DME-BF_3 complex is converted to potassium fluoborate by reaction with potassium fluoride in aqueous ethyl alcohol.

The KBF_4, after filtering and drying, is electrolyzed in a KCl bath at about 800 C. to deposit 200 g. of elemental B-10 per batch on a Monel cathode. There are five cells of special Hooker design, each drawing 500 amp. at 6 v. and running on 3½-hr. cycles.

Product is ground to 90% through 200 mesh, then water leached and acid leached to remove potassium salts, iron and other impurities. Dried B-10 powder, which resembles graphite, is packed in polyethylene bags placed inside 1-gal. friction-top metal cans.

Sewage Disposal Problems Spark New Process Probe

Zimmermann process—proven effective in eliminating pollution from waste sulfite liquor—is now being researched for large-scale sewage-disposal applications by Sterling Drug and Metropolitan Sanitary District of Greater Chicago.

Metropolitan Sanitary District serves an area of more than 900 sq. mi. with a sewage load equivalent to 8½ million people; if the joint project is successful, it can mean large savings to taxpayers. So far, lab tests on do-

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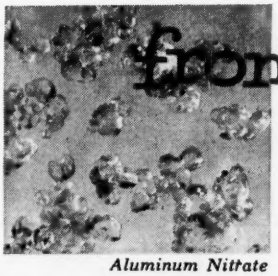
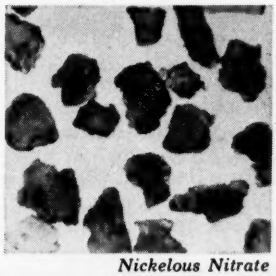
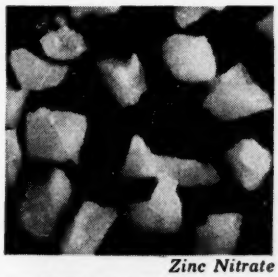


Aluminum Nitrate



Nickelous Nitrate



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Metallic Nitrate Crystals Enlarged 12 Diameters

To meet increased demands, Baker & Adamson has put extensive new facilities on stream for the production of aluminum, cupric, lead, nickelous and zinc nitrates.

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Baker & Adamson has long been a prime source for high purity metallic nitrates—Purified or Technical grade, for general manufacturing use; Reagent grade, for more exacting requirements.

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mestic and industrial sewage have been promising.

Process involves charging waste to a closed reactor with compressed air at about 800 psi. and near 500 F. Inorganic chemicals are oxidized, organic chemicals are both oxidized and cracked. End products after wet combustion are water with an acceptable chemical oxygen demand, carbon dioxide and a small amount of unoffensive ash.

Sterling Drug will build a pilot plant to evaluate cost of burning sewage sludge in concentrations of 2-6% or more. Research contract with the Sanitary District calls for Sterling to assume all costs for building and equipping pilot plant and to furnish supervisory and technical operating personnel.

Zimmermann process' first commercial trial will be in Aktieselskapet Borregaard's $3-million unit near Oslo, Norway, due on stream next year. It will handle waste liquor from a 500-ton/day pulp mill and pay for itself by converting heat of combustion into process steam. A smaller demonstration unit was built several years ago at Hammermill Paper's Erie, Pa., mill.

Three Firms Will Swell U. S. Zirconium Output

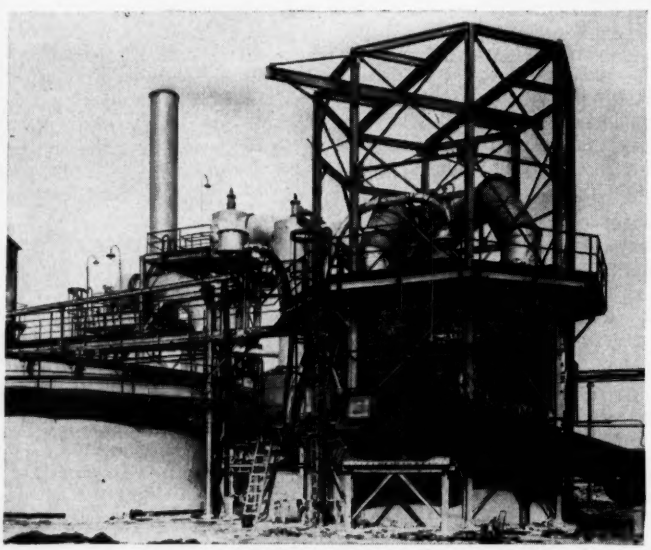
Zirconium, because of fast-rising demand in nuclear and chemical process industies, is scheduled for a sizable production boost.

Columbia-National Corp., owned by National Research Corp. and Columbia-Southern Chemical Corp., is building a plant near Pensacola, Fla., for producing zirconium sponge and hafnium. Columbia-National has a contract with Atomic Energy Commission for 3.5 million lb. of zirconium and hafnium metals and will supply other industries when the new plant reaches capacity.

U. S. Industrial Chemicals has revised upward the planned capacity of its Ashtabula, Ohio, zirconium plant, now abuilding, from 1.5 million lb./yr. to 2 million lb./yr. USI will supply its commercial- and reactor-grade zirconium as platelets rather than as sponge. Advantages of platelets, says USI, is that they are nonhygroscopic, nonpyrophoric and exceptionally pure.

Carborundum Metals Co., building a new 500,000-lb./yr. plant at Parkersburg, W. Va., will continue to use the commercially proven Kroll magnesium reduction process (*Chem. Eng.*, Dec. 1954, p. 113).

Stauffer Chemical Co. recently announced production boosts for zirconium and silicon tetrachlorides at its Niagara Falls, N. Y., plant. Zirconium tetrachloride is scheduled for a 40% boost; silicon tetrachloride, for a 20% increase.



New Phosphoric Plant Supplies Fertilizer Makers

Just on stream is U. S. Industrial Chemicals' new phosphoric acid plant at Tuscola, Ill., making location the only one in U. S. to produce all three ingredients—ammonia, phosphoric acid and sulfuric acid—for fertilizer manufacture. Process, using phosphate rock and spent sulfuric acid from nearby National Distillers' plant, gives byproduct sodium silicofluoride.

Canada's First Urea Plant Will Use Byproduct Gases

In revealing its plans to build an ammonia-urea plant at Hamilton, Ont., North American Cyanamid also adds its name to the list of companies using as a raw material hydrogen from stripped coke-oven gas (*Chem. Eng.*, Nov. 1955, p. 114).

Multimillion-dollar plant will be situated on the bayfront with easy access to water transportation and is due on stream by mid-1958. Initial production capacity will be 52,000 tons/yr. of anhydrous ammonia and 66,000 tons/yr. of urea.

Although many European plants have been producing ammonia via coke-oven gas, the route is not widely used in the U. S. and Canada.

Hydrogen and other raw materials—carbon dioxide from blast-furnace gas and nitrogen byproduct from oxygen extraction—will come from the adjacent steel mills of Dominion Foundries and Steel, Ltd. Cyanamid's large-scale operations will provide a profitable outlet for Dofasco's byproducts.

"Built for his grandson to walk on!"

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● Penta-protected wood lasts up to 4 times as long as untreated lumber. This kind of protection is a profitable investment for people with maintenance problems ... whether they're running a park department or a light and power company.

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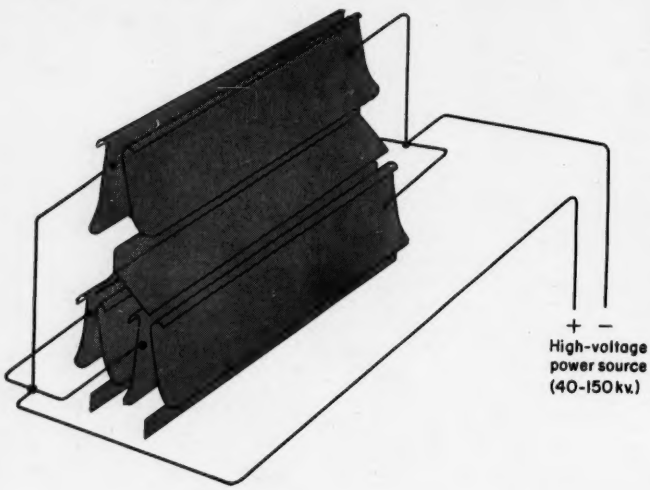
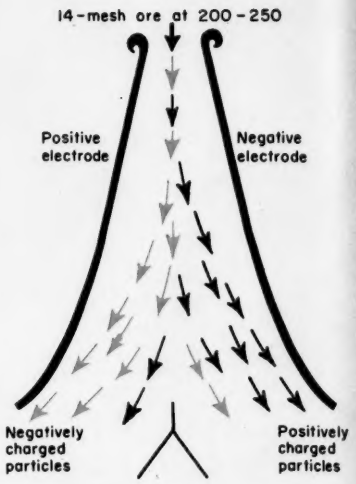




Separate Solids This Electrostatic Way

New free-fall design electrostatic separator shows promise in upgrading feldspar, potash and phosphate, works well when separating nonconducting minerals.

Many facts about the new electrostatic separator design developed by International Minerals & Chemical Corp. have just recently been made public.* Involving the free fall of charged solid particles between charged stationary electrodes, the new design represents a radical departure from electrostatic equipment previously available.

I. M. LeBaron and J. E. Lawver of IMC, looking for better ways to concentrate feldspar, potash and coarse pebble phosphate, came up with the free-fall electrostatic separator, which, they assert:

- Costs less to install.
- Has no moving parts, no dust problem, needs little maintenance.
- Requires no flow of current.
- Requires no contact between electrodes and ore particles.
- Gives good results when separating nonconductors from other nonconductors.

▶ **Production and Test Units**—IMC has been using the new design for over a year to concentrate feldspar at its Topsham, Me., plant. In the past few months production has been stepped up from 7.5 tons/hr. to 10-12 tons/hr.

A new four-stage electrostatic pilot plant was recently set up at Carlsbad, N. M., in an attempt to concentrate potash ores that are high in sulfate and under 20% K_2O. Object is to produce a saleable 60% K_2O concentrate. And at Mulberry, Fla., a 1,000 lb./hr. phosphate pilot plant is about to give way to a bigger production unit.

▶ **Free-Fall vs. Rotor**—Electrostatic separators currently on the market use a feeding rotor which is also one of the electrodes. These rotor-type machines have been used to great advantage in separating conductors from nonconductors. The minerals fed by the rotor can either be previously charged by contact friction or receive a charge as they pass through the electrostatic field between the electrodes. The charge on conductors is immediately dissipated upon contact with an electrode of the opposite sign.

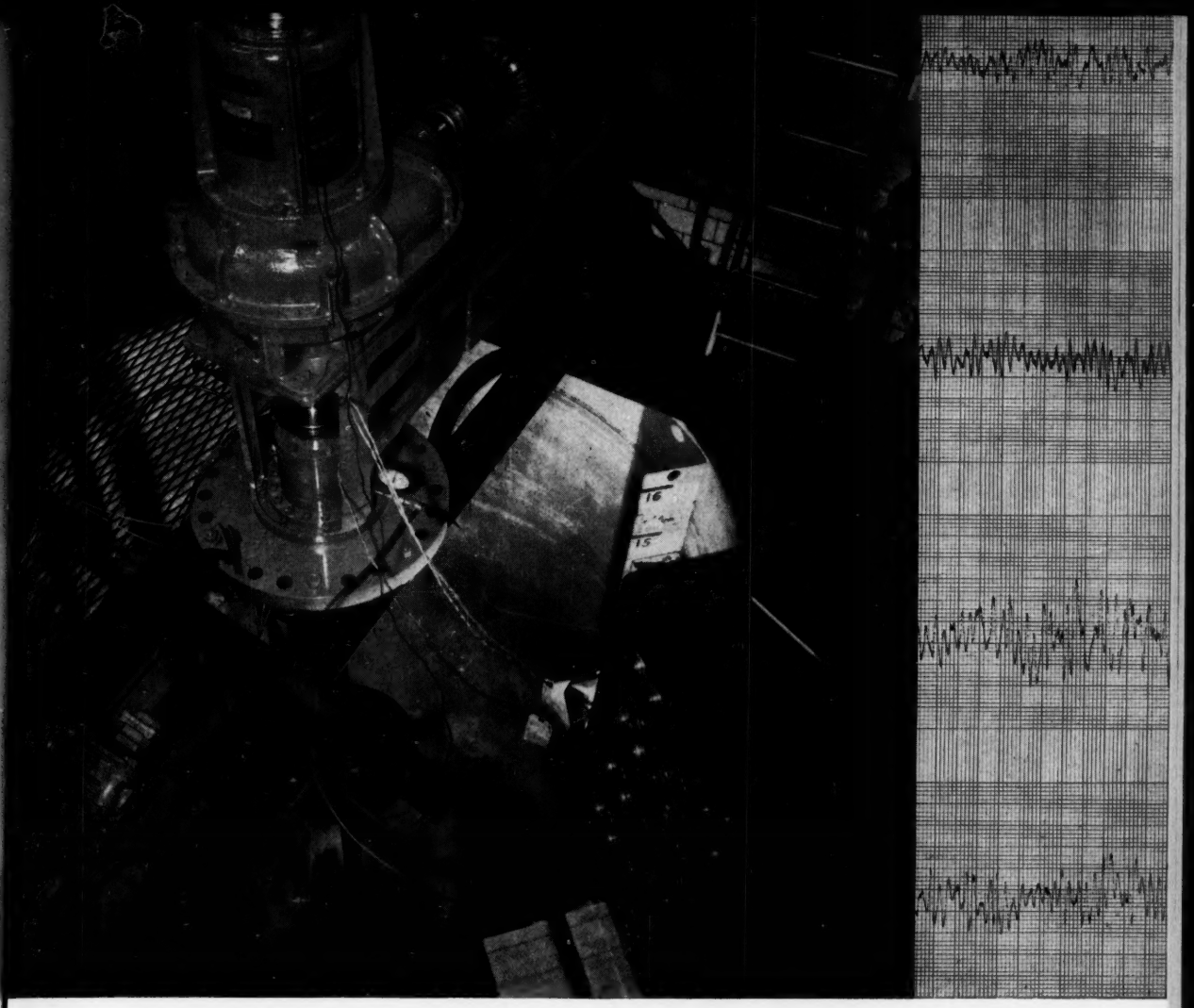
In the LeBaron-Lawver process, the charge is developed in the minerals by particle-to-particle contact or by contact with a metal surface. The ore then drops 6 to 9 ft. between oppositely charged electrodes (*see sketch, above right*).

IMC engineers found they had to alter the surface of the particles by heat treatment in order to develop the desired charges in the minerals to be separated. Temperatures to which ores are heated and cooled before separation, as well as shape of the electrodes and other operating factors, depend on the specific minerals involved.

▶ **Feldspar Beneficiation**—Because of the strong demand for high-potash feldspar of controlled purity, IMC investigated the use of electrostatic concentration to remove free quartz and increase the ratio of K_2O to Na_2O in the ore.

Tests with the LeBaron-Lawver process showed that a feed of about 8% K_2O and 74%

* At New Orleans meeting in February of American Institute of Mining, Metallurgical, and Petroleum Engineers.



How this shaft deflection test can give you **better fluid mixing**

Some secrets of efficient fluid mixing lie hidden beneath the tug-and-pull of fluids buffeting this LIGHTNIN Mixer's impeller.

These fluid forces are beginning to yield clues that can help you get improved mixer design and lower mixing costs.

Solving the seal dilemma

For example, if you're mixing fluids under pressure or vacuum, you probably want the great operating economy of a rotary mechanical seal.

You want the shaft diameter large enough to run with minimum deflection, to keep the sealing faces accurately aligned—but not larger than *really* necessary.

Seeing what deflection looks like

That is one reason why, as the 4-inch shaft on this 50-horsepower LIGHTNIN test unit revs up toward its natural vibration frequency, four MIXCO-designed strain-gage pickups start "taking the pulse" of the rotating shaft.

At the recorder, four electric styli trace a profile of the frequency and amplitude of shaft deflection during the run, in various liquid depths, and under different conditions of impeller size, location, and tank baffling. The data are accurate to 0.0005 in.

Combined with continuous torque measurements, this composite profile provides basic data for computing the stresses acting in the shaft.

Getting rid of a bearing

Efficient mixer shaft sealing is only one product of these test runs. They also permit highly accurate design of overhung shafts to operate without a steady bearing in the tank bottom, thus eliminating a major maintenance cost item.

This is one of the new directions MIXCO research is taking. Our research department welcomes the opportunity to cooperate with you in any phase of your work leading to more efficient fluid mixing.

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SiO_2 gave a product of 10.4% K_2O and 69% SiO_2 at a weight recovery of 72-75% and a feldspar recovery of 93-95%. On the basis of these results, the system was made an integral part of the Topsham operations.

▶**Electrodes at Work**—The hot feldspar feed (230 F.) to the electrostatic unit is 10-12 tons/hr. of −14 mesh nonmagnetic product from an Exolon magnetic separator. The ore falls as a curtain midway between an upper pair of first-stage electrodes. A concentrate is withdrawn by means of an adjustable splitter, and the tailing fraction is collected in a forming chute and fed to the lower, second-stage electrodes.

In the second stage a second concentrate is produced, which joins the first-stage concentrate to form the high-potash feldspar product. Also in the second stage (again by means of adjustable splitters), a middling fraction and a final tail are produced. The middling fraction is recycled to the first stage, while the tailing fraction joins the plant magnetic rejects.

▶**Controlled by Geiger**—Process control is attained by a Geiger counter, which every ½ hr. determines the K_2O value as a function of the naturally radioactive K-40 isotope. If any variation from standard grade of concentrate is indicated by the Geiger, a simple movement of the splitter setting realigns the unit.

The high-voltage system for the concentration tower can deliver up to 150 kv. Each 5×8-ft. electrode consists of a bank of 3-in. aluminum tubes spaced 1 in. apart. All the tubes are joined electrically, and a potential of 70 kv. is applied. Facing electrodes are 10 in. apart at the top and 36 in. at the bottom.

▶**Potash Beneficiation**—At Carlsbad, N. M., potash is dry mined and then wet concentrated. This involves recirculation of saturated brines, with the resultant difficulties involving disposal of brine and losses due to solution of KCl.

To electrostatically separate the two main components of potash ore (KCl and NaCl), IMC crushes the ore to −14 mesh for liberation. Fines produced in the crusher circuit must be minimized for best recovery and efficiency of concentration. Crushed ore is heated to 800-900 F. to deactivate the slimes which coat the particles. This allows a differential electric charge to form on cooling particle surfaces.

The 20-30% KCl ore, cooled to 225 F., enters the two-stage concentration unit at a rate of 25 tons/hr. This unit consists of a rougher pass and a scavenger pass, each containing three pairs of electrodes. While a d.c. potential of 90 kv. is used, the only power that is consumed is for losses (500 watts).

Many variables pertaining to the rougher operation have been studied. Sulfate minerals, as well as the amount of slimes adhering to the surfaces of particles to be separated, affect the efficiency of beneficiation. The degree of agitation during processing, retention time of the ore in the kiln, cooling methods and recycle loads have also been considered.

▶**Concentration of Phosphate**—High-grade concentrates from Florida coarse pebble (plus 1 mm.) phosphate deposits have long been recovered by washing and screening. IMC, realizing that treating the pebble electrostatically would not involve changing present plants (since it is dried anyway as standard practice), set up an electrostatic pilot plant at its Mulberry, Fla., phosphate works.

By crushing to liberate silica at about 14 mesh, moderate heating and then electrostatic treatment, ores running 60-70% tricalcium phosphate are upgraded to 73-77%. A double-pass unit of 1,000 lb./hr. capacity separates the negatively charged silica from the positively charged phosphate. Ore particles not freed by crushing, or too heavy to be sufficiently deflected by the 1×9-ft. electrodes, fall into a middling fraction, which is recycled.

▶**Promising Future**—Brian O'Brien (now research vice president, American Optical Co.) designed a free-fall separator many years ago, but it was never put to commercial use, and his patent has since expired. Carpco Mfg. Inc., builder of rotor-type electrostatic separators, has also been investigating the free-fall design and might soon have such machines available.

Many new materials will be added to the list of those that can be electrostatically separated as soon as the new design has been fully tested. Further fundamental progress in the electrical concentration of minerals depends largely on the rate at which our knowledge of solid-state physics can be increased.

Convention Calendar

American Oil Chemists' Society, Roosevelt Hotel, New Orleans, La., Apr. 29-May 1.

American Ceramic Society, 59th annual meeting, Statler Hilton Hotel, Dallas, May 5-9.

Electrochemical Society, symposia on theoretical and industrial electrochemistry, Hotel Statler, Washington, D. C., May 12-16.

Purdue Industrial Waste Conference, Purdue Memorial Union Bldg., Lafayette, Ind., May 13-15.

American Petroleum Institute, Division of Refining, midyear meeting, Sheraton Hotel, Philadelphia, May 13-16.

American Institute of Chemical Engineers, New Jersey Section, annual symposium, Military Park Hotel, Newark, N. J., May 14.

American Chemical Society, Division of Rubber Chemistry, in conjunction with Rubber Division of Chemical Institute of Canada, Sheraton-Mt. Royal Hotel, Montreal, Que., May 15-17.

American Institute of Chemists, annual meeting, Sheraton-Mayflower Hotel, Akron, Ohio, May 22-24.

American Society for Quality Control, 11th annual convention, Masonic Temple, Detroit, Mich., May 22-24.

XUM

ideas *new ways to solve problems — with chemicals*

NEW HEAVY-DUTY LIQUID DETERGENT FORMULAE --- mixtures of triethanolamine, nonionic surfactants and carboxymethyl cellulose --- have shown better cotton detergency under test than the more usual phosphate-alkylaryl sulfonate liquid mixtures, and have exhibited a washing action equal to that of heavy-duty powders.

Liquids have these advantages over powders: (1) no dust; (2) can be packaged in metal or glass containers which do not become soggy; (3) dissolve readily in hot or cold water; (4) take up less space because of high density.

A RECENTLY DEVELOPED INSECT REPELLENT designed specifically to shoo horn flies away from cattle, is reported to contain an ethylene oxide-ortho-cyclohexyl phenol condensation product as the active ingredient.

A DEVICE FOR MINE BLASTING employs nitrogen tetroxide and a hydrocarbon as the explosive mixture. It consists of an unpartitioned container holding frozen nitrogen tetroxide, a separate body of frozen hydrocarbon and a detonator.

A hole is bored in the solid composite and the device is placed inside. The contents of the container are melted, tetroxide mixes with hydrocarbon, and the detonator explodes the mix.

NEW HYDRAULIC FLUIDS take advantage of the stability, solvent properties and desirable temperature characteristics of ethylene glycol.

Formulations include: a magnetic fluid composed of 60-90% iron particles and 10-40% of a liquid hydrocarbon containing up to 5% ethylene glycol; a transmission fluid for automobiles consisting of 50% water and 50% ethylene glycol plus additive traces; a hydraulic pressure-transmitting fluid made up of 5-30% of a polyethylene glycol lubricant, 5-30% of a liquid soap and 40-90% of ethylene glycol solvent.

Dept. AP 4-5-1

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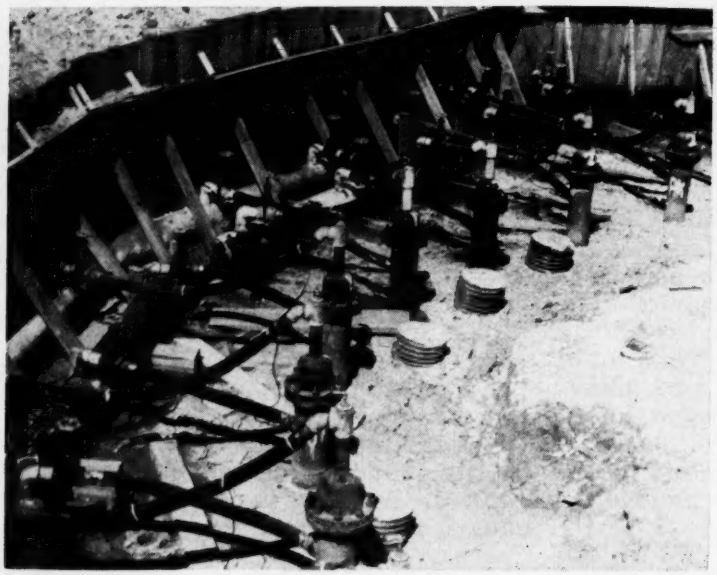


TWENTY-EIGHT steel pipes carry refrigerated brine 187 ft. into earth.

Freeze Soil to Sink Shaft

Morton Salt used novel technique to open up new working level in salt mine. Freezing the earth before shaft excavation overcame difficult soil conditions.

Morton Salt Co. is now mining salt at Weeks, La., through a shaft which represents the third successful application of the soil-freezing method on this continent. Morton's shaft is unique in being the first one in the Western Hemisphere to be sunk by the freezing method in porous formations subject to the action of tidal waters.

Completion of the shaft last September came after about two years of exploration, development and sinking work by a joint group of Winston Bros. Co., Missouri Valley Constructors and Consolidated Western Steel Div., U.S. Steel Corp. This group previously had also sunk mine shafts by soil freezing for a potash producer at Carlsbad, N. M., and for a salt concern at Ojibway, Ont.

The freezing method was first conceived in 1883 by a Belgian mining engineer, but until recently had not been used in the U. S. Soil freezing essentially consists of placing a heat-transfer surface in the earth and circulating chilled brine through the elements until the earth is frozen solid. Freezing the earth prior to starting excavation can be resorted to when subsurface water and saturated soils of low shear value are encountered.

▶ **Allows New Facilities**—Latest application of freezing at the Weeks Island salt dome was for a shaft going down about 900 ft. This new 18-ft.-I.D. shaft and its auxiliary facilities adds a second mining level at 750 ft. below sea level. (Morton had been working the dome for 50 years at the 500-ft. level). Freezing was effected to a depth of 187 ft.—approximately 27 ft. into the top of the dome.

An exploration of subsurface conditions had revealed fine-grain sand which ruled out all cementation methods. Analysis of comparative costs and operating factors pointed to freezing, rather than an open caisson.

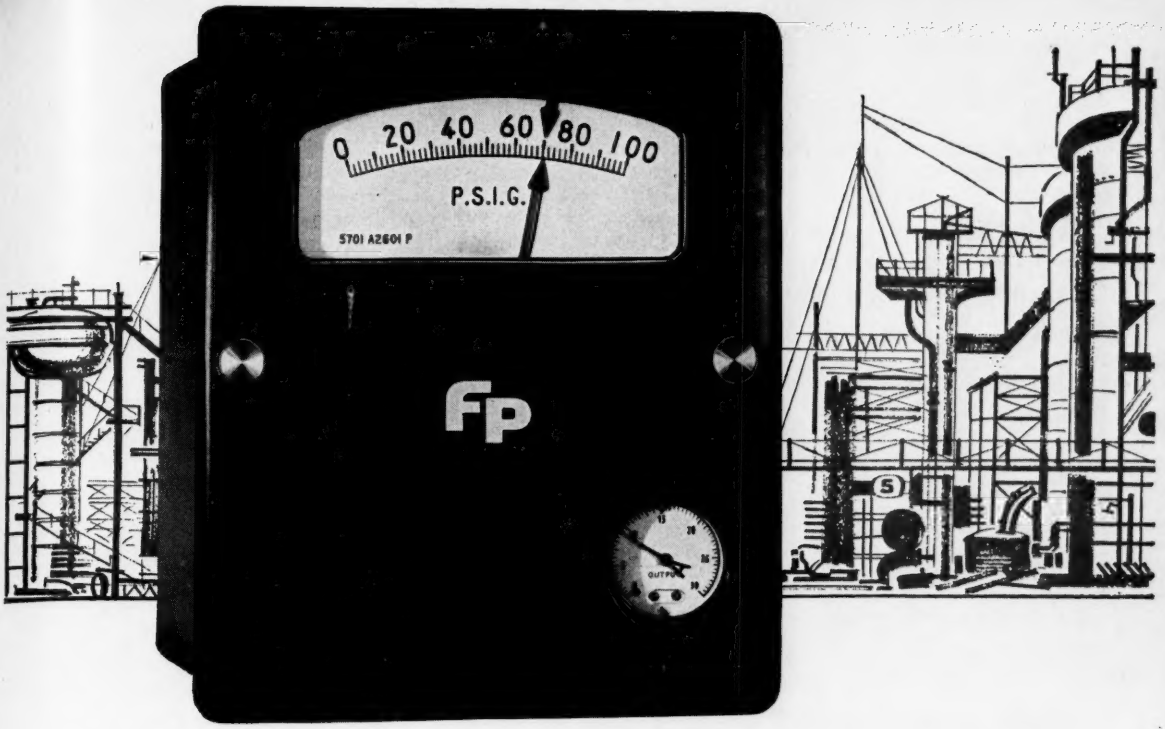
▶ **Freezing the Soil**—The freezing method as employed at Weeks Island consisted of drilling 28 holes, 3½ ft. apart, about the circumference of a 33-ft.-dia. circle. Holes were 8 in. dia. and were drilled to a depth of 187 ft. They were cased with 6-in. pipes capped on the bottom; then 2-in. tubing was placed inside this casing. Refrigerated brine was admitted to the holes through the inner tubing, descended to the bottom and rose in the annular space between the tubing and the casing.

During drilling, a condition of highly saline subsurface water from the Gulf of Mexico was encountered. Thus, in order to avoid structural defects in the ice wall, an isotherm of −6 F. (the eutectic temperature of sea water) had to be maintained at a substantial distance from the centerline of the freeze holes. To accomplish this, a two-stage ammonia refrigeration system of 80 tons capacity was used to cool the 1,000 gpm. of circulating calcium chloride brine to a temperature of −25 F.

▶ **Dig the Shaft**—After a two months' wait for formation of the ice wall, sinking of the shaft commenced. Sinking progressed rapidly to 74 ft. below sea level without the necessity of blasting. Once the frozen water-bearing formations were encountered, blasting was accomplished with a series of relatively shallow rounds.

When the shaft had progressed to a depth of 219 ft., a permanent water seal was made by the combination of an asphaltic coating and the injection of sodium silicate at high pressure. Work then progressed rapidly to the mining level of 824 ft. and beyond to the loading station near 900 ft.

▶ **Reduces Excavation Hazards**—Freezing the earth offers a method of temporary soil stabilization—not only for sinking shafts, but also for laying foun-



new small instruments in fiber glass cases indicate . . . transmit . . . control temperature or pressure

NOW . . . instruments as corrosion-resistant as the equipment they control! Every instrument in Fischer & Porter's new 1450 Series is housed in a fiber glass reinforced polyester case resistant to acids, alkalis, salts, solvents, dust, and weather. You can place indicators, transmitters, and controllers wherever you want—inside or out—without regard for corrosive fume and splash. The protection is built right into the housing . . . nothing to wear away or scratch off . . . no coatings to renew. The first such equipment available for process instrumentation, Series 1450 brings a new flexibility and freedom to instrument installation.

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As pneumatic receivers, 1450 instruments accommodate 3 to 15, 3 to 18, or 3 to 27 psi signals.

Instrument Options:

Single indicator • dual indicators • single indicator with dual alarms • indicating controller with any mode of control • indicating transmitter. Transmitter can provide pneumatic outputs, resistance outputs, or differential transformer outputs.

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Mounting:

Suitable for surface, pipe, or panel mounting. Panel cutout size is 8¾" x 10¼".

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dations. Many locations that have been avoided because of the treacherous nature of the soil can now be excavated without fear.

How to Revamp One Kiln To Do the Work of Four

What do you do when you've installed three 100-ton/day, 50-ft.-high vertical lime kilns and you get nothing but trouble—kilns can't keep pace with demands?

That's the question Electro Metallurgical Co.'s engineers were asking themselves in 1946 after they replaced rotary lime kilns with vertical ones to solve an air-pollution problem at Ashtabula, Ohio. Electromet engineers at Metals Research Laboratories, Niagara Falls, N. Y., went to work to solve the production problem.

▶ **Now in Lime Business**—After several years and an extensive revamping job, Electromet can tell how it uncorked the bottleneck so well that it's now in the lime business.

It didn't take Electromet's engineers long to see that the vertical design (11x11-ft. internal cross-section, 6-in. induced draft, producer-gas fuel) was not adapted to burning the 3¼x2-in. limestone available at the plant. Kilns suffered from poor heat distribution, severe hanging and serious refractory damage. These symptoms were reasons why lime producers preferred rotary kilns despite higher cost and greater fuel consumption.

Electromet figured the answer lay in tight control of heat input and fuel distribution across the kilns, and fast vertical movement of limestone was needed to counteract hanging.

▶ **Revamp Quadruples Output**—Induced draft was increased from 6 in. to 28 in. (water gage), boosting specific production rate from 1 to 4 tons/day per sq. ft. of cross-section. Inverted narrow channels replaced the gas offtake pipes to prevent stone from being sucked out of the kiln.

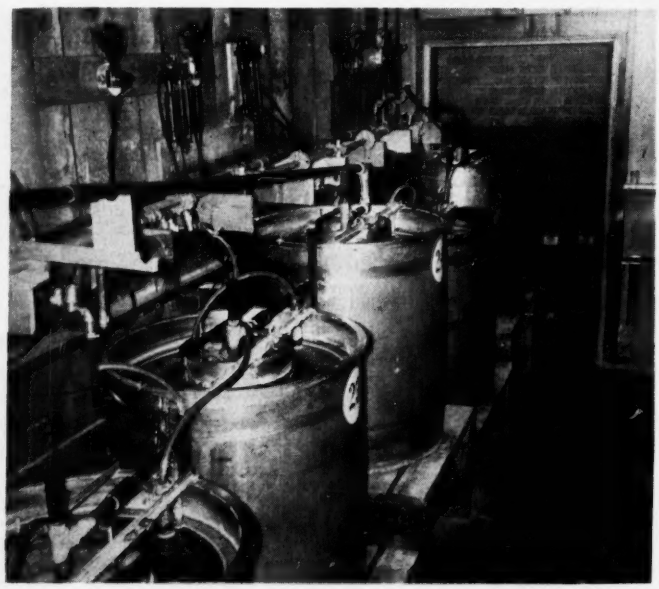
Radical changes were needed to get accurate fuel distribution. Failure of refractory ducts led Electromet to develop steel ducts consisting of heavy H-beams enclosed in a water-cooled box and traversing the kiln. Partitioning the beam in the middle gave four ducts, two from each end. Pipelines inside the beams discharge fuel at the desired rate through outlets in the ducts. Beams were installed at two levels to control flame temperatures.

These changes have stepped up production for each kiln from 100 to 480 tons/day.

▶ **Staged Burning Breaks Hangs**—Beams at two levels control maximum flame temperatures without detracting too much from heat evolution above 1,000 C. At the first burner level, initial combustion stage produces a gas of low calorific value which burns with highly superheated air in the kiln. At the upper burner level, third combustion stage gives a hot gas which, in the fourth stage, burns with residual oxygen in combustion products from the lower zones.

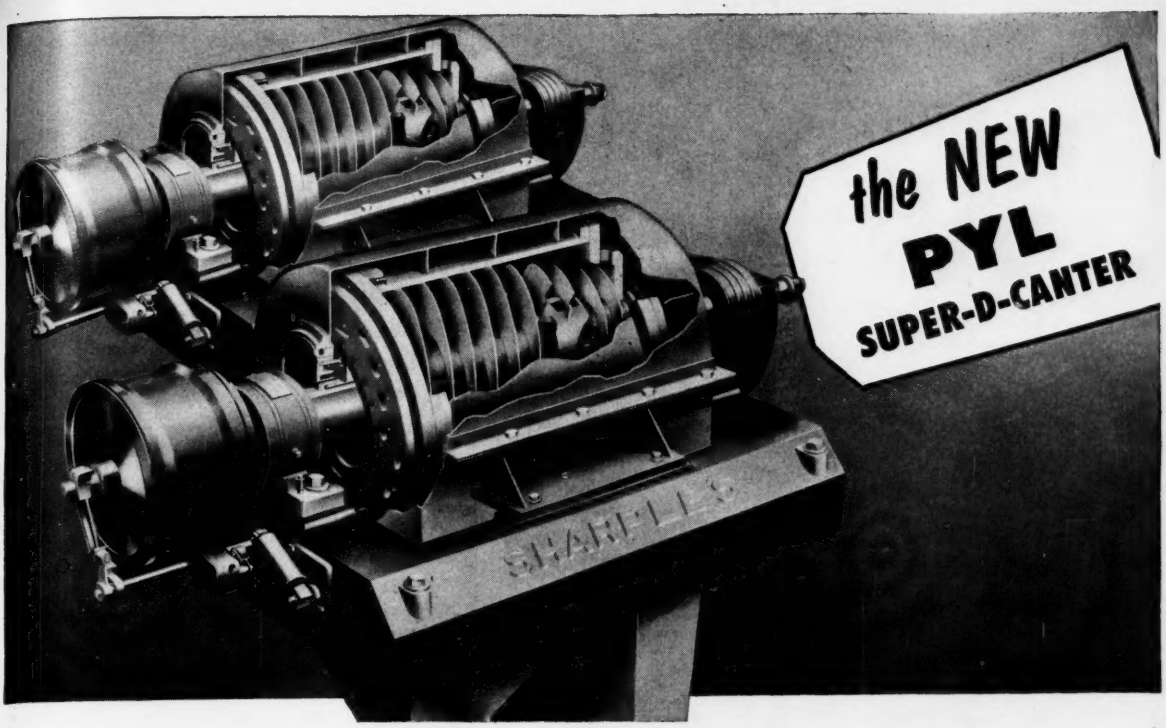
These controlled-combustion stages reduce localized high flame temperatures, and hanging becomes infrequent. Since some hangs do occur, mechanical stokers above the lower burner level periodically break up any accretions.

Although extensive revamping cost Electromet a lot of time and money, it promises to pay off handsomely.



Continuous Ion Exchange Bids for Uranium Jobs

Continuous countercurrent ion exchange is put through its paces in this pilot plant at the Tucson laboratories of Infilco, Inc. Techmanix Corp. and Infilco are working out the process for uranium recovery from leach pulps as an improvement over column and resin-in-pulp ion exchange (see p. 228) and as a means of maintaining ion exchange's competitive position vs. solvent extraction in the uranium industry. Pilot plant uses four 30-in.-dia. resin-pulp contactors, adapted from the design of Infilco's Aero-Accelator, a machine used for water and sewage treatment. Process may have wide application in other fields, such as sugar processing and pharmaceuticals.



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The new Sharples PYL Super-D-Canter has been designed to provide greater over-all efficiency and capacity for the continuous removal of solids from, and improved clarification of slurries.

This new larger Super-D-Canter offers exceptional processing flexibility to recover and dewater crystalline type solids from slurries; to remove amorphous solids from suspensions; to classify solids by particle size; to clarify liquids.

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The laboratory size P-4 Super-D-Canter is available for field testing on a moderate rental basis.

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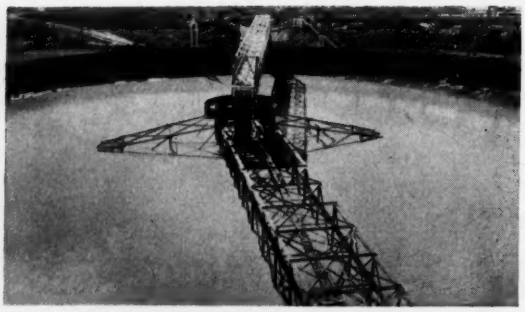
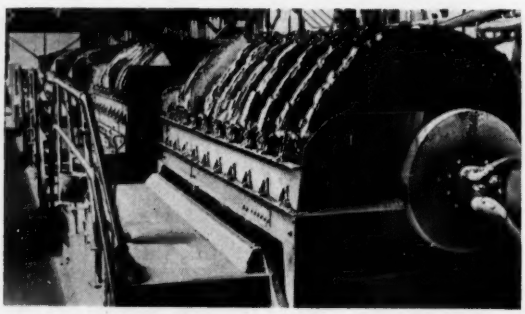
New Flocculants Yield Real Benefits



In thickening operations, one uranium processor is saving $3,000/day in return for an expenditure of $15/day for a flocculant. One thickener now does the job formerly requiring five thickeners, two banks of filters and several earthen ponds.



In filtering operations, another uranium processor found his entire plant capacity limited to half of design rate. Use of 0.2 lb. flocculant per ton of ore has doubled filtration rate, enabling plant to achieve design conditions.

BY speeding up settling and filtering operations, a new class of organic flocculating agents has already made a place for itself in processing such materials as uranium, copper, gypsum, alum, cement, rare earths, magnesia, clay, borax, potash, soda ash, lithium, petroleum wastes and wood pulp.

Improvements in flocculation activity in the order of ten to several hundred fold have been credited to their use. Practical benefits include:

- Increased capacity for existing plants and reduced capital costs for new plants.
- More efficient use of valuable land or (especially in Canada) indoor space because of reduced area requirements for settling tanks and filters.
- Performance of separations which had previously been economic impossibilities.

That they do work is attested to by scores of commercial applications. But why they work is still pretty much a scientific mystery. The Edisonian technique must therefore be used to discover whether a given flocculant can make technical-economic improvements in a given liquid-solids separation.

▶**Uranium Boon**—Most publicized, and probably strongest, gains have been made in uranium processing (*see above captions*). Processors separating uranium-containing solutions from hard-to-handle clay slimes by countercurrent decantation originally used glue as a flocculant.

Now one of the new flocculants, Dow's synthetic Separan 2610, has gained predominance among U. S. processors. Kerr-McGee's Shiprock, N. M., uranium mill (whose solvent extraction process was described last month in *Chemical Engineering*) uses Separan to help clarify uranium-containing solution supplied to both its new solvent extraction section and its fixed-bed ion exchange section. In Canada, another new flocculant, Stein Hall's natural guar gum called Jaguar, has had much success.

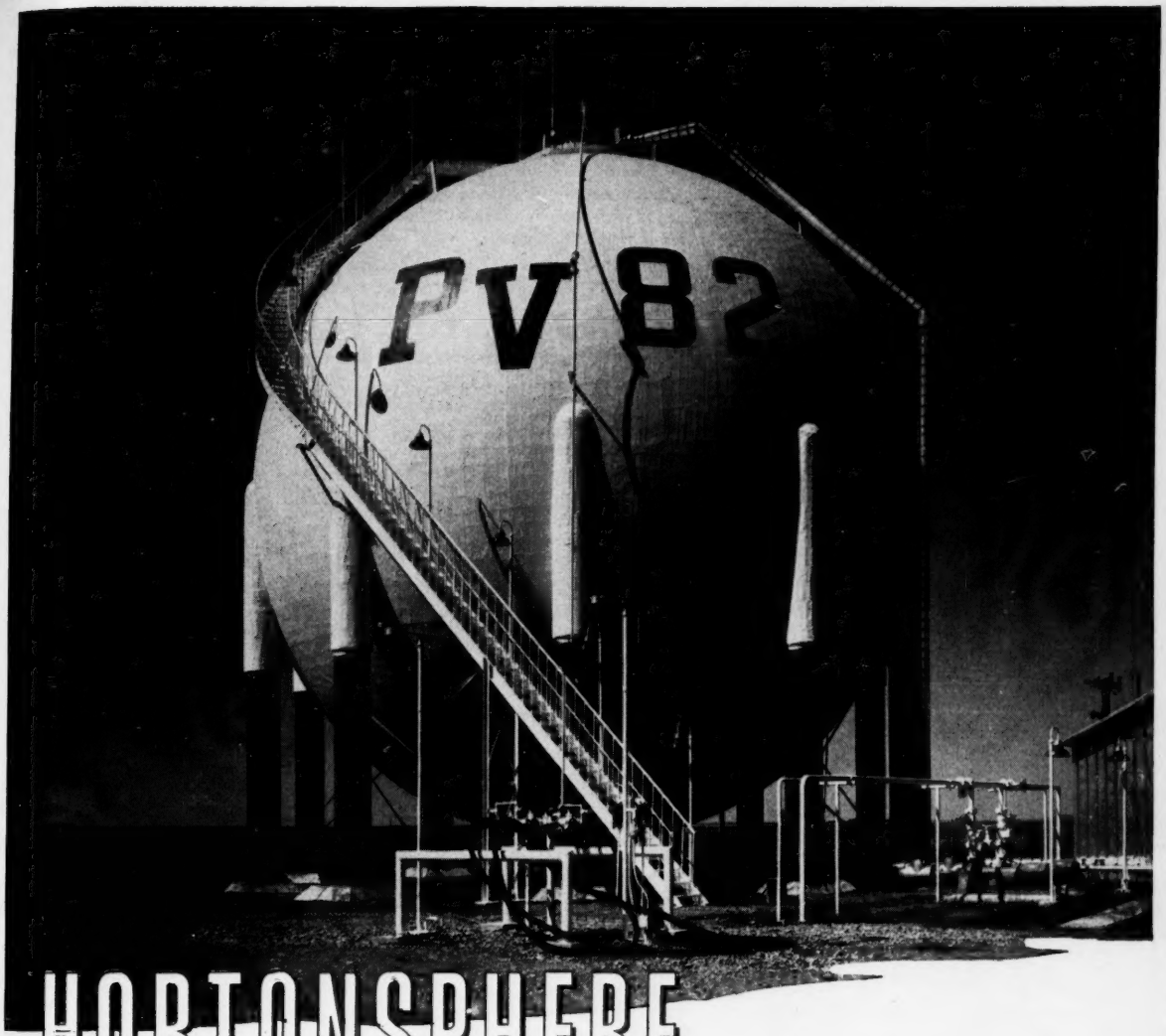
Though more expensive in first cost—with Separan at upwards of $1/lb., Jaguar at about 30¢/lb., compared to glue's 15¢/lb.—the new flocculants are effective in smaller quantities. And, on a particular slime, one of them may do a job economically which can scarcely be done at all without it.

▶**Rapid Growth**—Born about 1954, the flocculants have made their gains in remarkably short time.

Among the new synthetic materials, in addition to Separan: American Cyanamid's Aerofloc, B. F. Goodrich Chemical's Good-Rite, Monsanto's Lytron. Among the new natural products, in addition to Jaguar: Burton Co.'s Burtonite and General Mills' Guartec and Gum 39.

Separan is described as a high-molecular-weight polyacrylamide. American Cyanamid's most-used Aerofloc, No. 550, is described as a hydrolyzed polycrylonitrile, as is Monsanto's Lytron.

▶**Common Ancestry**—In some



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• This 15,000-bbl. Hortonsphere®, insulated and refrigerated to help reduce pressure of stored anhydrous ammonia, is located at the Curry Chemical Company, Funk, Nebraska. It has been designed to withstand internal pressure and will not allow contents to escape as long as the setting of the pressure relief valves are not exceeded. Hortonspheres, for the storage of such liquids as anhydrous ammonia, butadiene, and other volatile liquids, are available in sizes to 30,000 bbls. Write our nearest office for complete information or quotations.

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quarters, a common chemical ancestry is attributed to these new synthetic flocculants: the soil conditioners (such as Monsanto's Krilium, a sodium salt of acrylonitrile), which were introduced and widely publicized circa 1951. Clumping or flocculating effect of these conditioners on clay soils is one of their most valuable features as moisture-retention aids. The same effect is said to apply in the case of the new flocculants.

Of the synthetics, Separan appears to have been the most universally useful so far. It has been successful in systems covering a wide pH range. The others have been used chiefly with neutral or alkaline systems. However, American Cyanamid is bringing out Aerofloc 3000, a high-molecular-weight polyacrylamide like Separan, which the company believes will compete over the entire pH range.

The natural flocculant, Jaguar —essentially a straight-chain mannan with an average molecular weight of 220,000—has been successful in both acid and alkaline systems.

▶ **Vs. Inorganic Aids**—In many cases, the degree of flocculation which can be obtained with these new organic flocculants is outstanding when rated on the same performance scale with traditional inorganic flocculants.

The organics are generally characterized as water-soluble compounds of high molecular weight. These large molecules have solubilizing groups on them which have affinity for the solids in question. They flocculate the solids by attachment to the particles, lacing them together by providing true moleucular links.

They are not as limited as the inorganics, like alum or ferric chloride. These become uneconomic as the concentration of solids to be removed rises, because the amount of flocculant required is a function of the amount of suspended solids.

▶ **Vs. Older Organic Aids**—Also, the new organics often have an entirely different magnitude of effect on liquid-solids separation than older organic flocculants, like natural starches or glue.

For example, one very large alum producer had been using 300 lb. glue per batch of alum to obtain adequate settling rates. This much glue was replaced with 3 lb. of Separan, which gave him a settling rate three to four times what he had been getting. And the solids compacted so much better that the over-all efficiency of his process was increased by 21%. Thus, $3 worth of Separan replaced $45 worth of glue and did a better job, even though glue sells for 15¢/lb. vs. Separan at about $1/lb.

In the coal industry, where slimes washed off the coal must be settled, starch may be used at loadings of 5-7 lb./ton, but Separan is usually used at 0.02–0.05 lb./ton.

In general, there is a line of diminishing returns in regard to the amount of a newer flocculant used in a given system. Increasing amounts improve flocculating effect up to a point beyond which further additions show no improvement.

Under the heading of filtration efficiency come recitals like the following. Improvement in results of primary filtration using a total of 0.10 lb. Jaguar per ton of solids as against 0.295 lb. glue: increased thickness of dry cake drawn per unit of time, 18.0%; increased water wash drawn through cake, 22.0%; reduced moisture content of final cake, 3.2%. For secondary filtration, increase in dry cake drawn is 34.4%, reduction in moisture content is 12.7%.

▶ **How Applied** — Variables which affect efficiency of the new flocculants, in addition to amount of reagent used and pH of the system, include method of addition (multipoint addition of reagent appears to be much more effective than one addition) and nature of the slime or solids to be flocculated. There are instances where one of the new flocculants is being used with great success at, say, one uranium plant. At a similar plant nearby, glue is still preferred as a beter performer.

A minium of liquid turbulence and mechanical handling are demanded by poorer floc strengths in pulps created by the new flocculants. Ideal method for transporting these pulps is probably gravity flow.

▶ **How Selected** — Empirical trial-and-error approach to choice and use of these flocculants is necessary because the mechanism of flocculation is not understood. Changes in structural characteristics of a floc in relation to chemical nature of flocculant are unknown.

And in all cases, it is certainly necessary to take a sharp look at the economics of their use. For, in addition to the many hands-down success stories, come stories like this:

To clarify 10,000 gpm. of scrubbing water to attain 5 gr./gal. in the overflow takes a thickener 90 ft. dia. by 20 ft. deep when no flocculant is used. Using Separan at 0.00313 lb./1,000 gal., a 100% increase in capacity is gained. Therefore, a 55-ft.-dia. thickener can handle the job.

But daily cost of Separan at $1/lb. would be $45, annual cost $16,425. Cost of a 55-ft. thickener is about $30,000; cost of a 90-ft. thickener, about $50,000. Difference is equal to cost of Separan consumed during 15 mo. of operation, an attractive payout time for the incremental investment.

Linear Poly: U. K. Slated For Raft of Developments

Chemical news from Britain underscores a many-thousand-ton/yr. boost in store for high- and low-pressure polyethylene.

Large-scale or pilot-plant production is planned by four companies: Shell Chemical at Partington, British Hydrocarbon Chemicals and Union Carbide at Grangemouth, Monsanto Chemicals at Fawley.

Shell, bringing on stream its 1,000-ton/yr. pilot plant, will use the Ziegler low-pressure process, while British Hydrocarbon will use Phillips' low-pressure process to make 11,000 tons/yr. Carbide's unit, to produce 11,500 tons/yr., will cost about $12.6 million. Monsanto's 10,000-ton/yr. plant is part of its $23.8-million petrochemical expansion plan at Fawley.

British Hydrocarbon recently brought on stream ethylene and ethanol units at Grangemouth and still has to bring on butadiene and propylene tetramer units.

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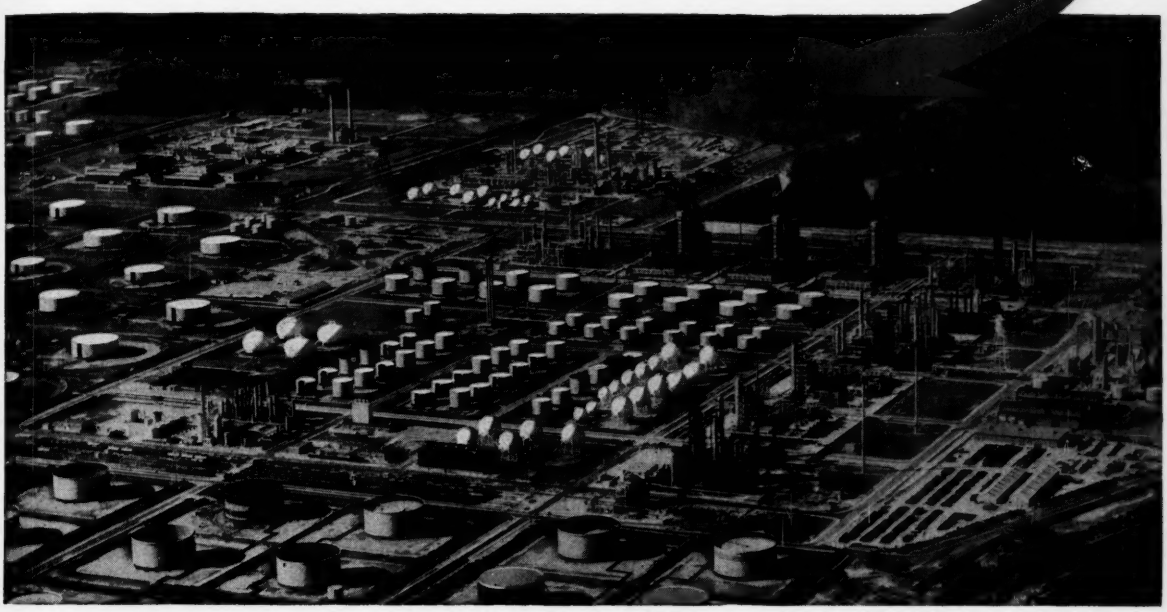
butyl rubber

Nation's capacity will be increased 33⅓% with new PCI plant to be built here by Foster Wheeler



Here at Lake Charles, Louisiana, Petroleum Chemicals, Inc. will expand its petrochemical facilities with the addition of a butyl rubber plant — to be built by Foster Wheeler.

With an initial capacity of 30,000 tons per year, this $17,000,000 plant will be the first one built since the war and its operation will increase the country's total butyl rubber capacity by about one third. This new plant will obtain its raw materials from the hydrocarbon streams available at the Lake Charles refineries of Cities Service and Continental Oil Companies, joint owners of Petroleum Chemicals, Inc.

Foster Wheeler is also building a 300 ton/day ammonia synthesis plant at the same site.

This is another example of how Foster Wheeler's design, engineering and construction experience is helping to meet the exact requirements of petroleum, chemical and petrochemical processing plants the world over.

Foster Wheeler Corporation, 165 Broadway, New York 6, N. Y.

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Nuclear Radiation Proves Worth in Tire Vulcanizing

Researchers at B. F. Goodrich are making better automobile tires by vulcanizing with nuclear radiation.

Irradiated tires, says Goodrich, are expected to wear longer and resist deterioration better than tires vulcanized by conventional methods. According to Goodrich scientists, nuclear vulcanizing links carbon atoms in the rubber molecules directly, rather than through sulfur atoms as does conventional vulcanizing. With nuclear method, tires are vulcanized without heat, sulfur or accelerators.

New method is being tested at Atomic Energy Commission's National Reactor Testing Station in Idaho.

The tire, in a steel mold, is vulcanized by rotating it over radioactive fuel elements in a 17-ft.-deep, water-filled canal. Researchers claim that in the future tires could be vulcanized cold on a production basis more rapidly than they are with present methods.

Goodrich, in 1933, patented a process for vulcanizing rubber by means of high-energy electrons.

Du Pont Plans Outlays At Four Chemical Sites

Simultaneously, Du Pont and its affiliate, Du Pont of Canada, have announced plans embracing new facilities for producing cellophane, urea-ammoniating solutions, sodium metal and chlorine.

In the U. S., Du Pont is planning its fifth cellophane plant near Tecumseh, Kan. Plant will turn out 50 million lb./yr. and is slated to go on stream early in 1959. Expansion of Du Pont's ammonia-liquor facilities at its Belle Works in W. Va. will be completed in 1959. Plant's extensive high-pressure synthesis facilities are gradually being converted to use natural gas instead of coal as a basic raw material. At Memphis, Tenn., Du Pont is adding a sodium and chlorine manufacturing unit that will boost firm's capacity by over 50%. Both products currently are made at Niagara Falls, N. Y. Memphis plant will start up next year.

Du Pont of Canada says engineering is well along on its second cellophane plant to be built at Maitland, Ont. Company's present plant at Shawinigan Falls, Que.—expanded nine times since 1945—has reached peak capacity. New plant's cost and on-stream date are not yet available.

More Processing, Power For Nuclear Industry

Latest raft of developments in nuclear industries involve new milling and processing operations and more plans for nuclear reactors.

Kerr-McGee Oil Industries is reported to have signed an agreement with Atomic Energy Commission to build a 3,300-ton/day uranium mill in the Ambrosia Lake, N. M., area. This would be the largest mill in the U. S., topping Anaconda's 3,000-ton/day unit in nearby Grants, N. M. (*see* Process Flowsheet, *pp.* 228-231).

Allied Chemical & Dye's General Chemical Div. will build its uranium hexafluoride plant (*Chem. Eng.*, Jan. 1957, p. 110) at Metropolis, Ill., on the Ohio River. Allied is slating future production of other fluorine chemicals at this new plant location.

Private utility companies are in a big hurry to get the ball rolling in the commercial atomic power field. Twelve Midwest utility companies have worked out a proposal with AEC to build a 13,000-kw. prototype research reactor by 1962, at a cost of between $15 and $31 million. By this date, says AEC, it hopes to have abuilding a full-scale, 200,000-kw. reactor, patterned after the design of this prototype.

Sulfur Recovery Process Slated for Probing

Agreement for operating a pilot plant to investigate processes for recovery of elemental sulfur from sulfur dioxide-bearing gases was recently concluded between International Nickel Co. of Canada and Texas Gulf Sulphur Co.

Pilot plant will be built near Inco's new iron ore recovery plant at Copper Cliff, Ont., and will use sulfur dioxide-rich gases from fluid-bed roasting of iron sulfides. It will consist of two sections, one for scrubbing and cleaning gas and one for reducing sulfur dioxide to elemental sulfur.

Texas Gulf will investigate use of natural gas (when it becomes available), propane and heavy fuel oils, among other reducing agents, for use in the recovery process.

Boron Compounds: More Spotlighted Than Ever

With the ground-breaking for Callery Chemical Co.'s $38-million boron-based high-energy fuel plant at Muskogee, Okla., boron news is momentarily centered around missile fuels again.

But not all boron news involves new fuels and, conversely, not all fuel news concerns boron.

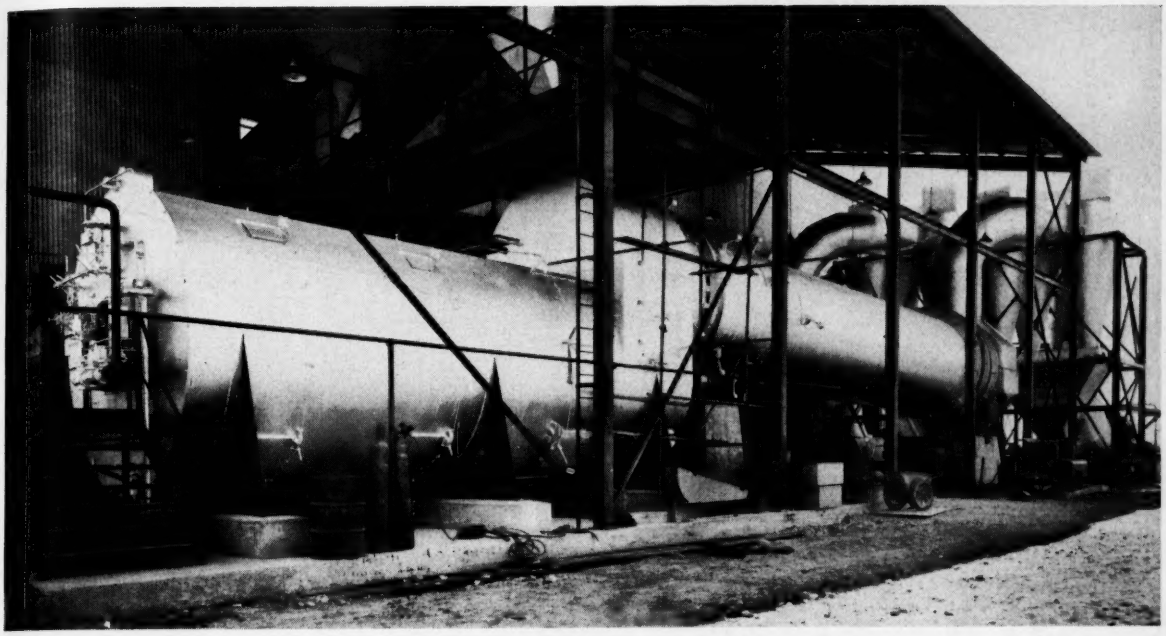
Atomic Energy Commission has announced that elemental boron-10 — important neutron-absorbing isotope—is now commercially available from Hooker Electrochemical Co.'s plant near Niagara Falls, N. Y. (*see pp.* 148-150, 176).

From the Max Planck Institut, Muelheim-Ruhr, West Germany, comes word of a new method for producing borohydrides—intermediates for boron-based, high-energy fuels (*Chem. Eng.*, Sept. 1956, p. 113). Boron trialkyl compounds are hydrogenated under pressure together with a tertiary amine, producing an N-trialkyl borazane. Treating this with a suspension of metal hydride powder in an inert solvent at 100 C. gives 100% pure borohydride. So far, the method has been used to produce Li, Na, K, Mg and Ca borohydrides.

Air Armaments Div. of Sperry Gyroscope Co. will probe nitroglycerine-based fuels for missile systems at its new propellant devices laboratory at Great Neck, N. Y. Sperry has no plans for researching boron-based fuels.

Helping others produce a better product...

STANDARD HERSEY DRYERS



ORTHO

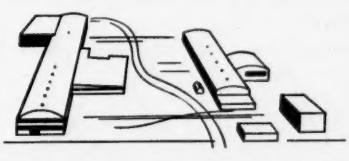
TO ENRICH THE SOIL FOR GREATER FOOD SUPPLY CALSPRAY'S© NEW PLANT IS ON STREAM... WITH STANDARD-HERSEY DRYERS!

To provide better fruit, vegetables, meats ... and lower farmers' "production" costs, California Spray-Chemical Corporation's new plant is now on stream at Richmond, California, increasing the production of its famous-for-quality ORTHO Fertilizer. With a rated capacity of 300 tons-per-day, Calspray's new plant uses two *job engineered* Standard-Hersey dryers designed and built by the experienced engineers of Standard Steel Corporation ... a world leader in better designs of dryers, granulators, and coolers. Wide range and flexibility are provided to make almost any desired grade of fertilizer.

Regardless how tough the problem, if you're looking for a *job-engineered* rotary unit, you'll look to Standard Steel.

IF YOU HAVE A PROCESSING PROBLEM!

Standard Steel welcomes the opportunity to discuss with you any problems you may have in drying, cooling, or calcining. Our laboratory pilot testing equipment determines beforehand the best equipment for your problem.



STANDARD STEEL ACQUIRES LEADER IRON WORKS

Since Leader 1888

To meet the ever increasing needs of its world-wide customers, Standard Steel Corporation recently purchased the Leader Iron Works at Decatur, Illinois. Founded in 1888, Leader is well known for its work in the food, chemical and petroleum industries. In addition to its customary fabrication, Leader will now manufacture Standard's line of heavy processing and road construction equipment.

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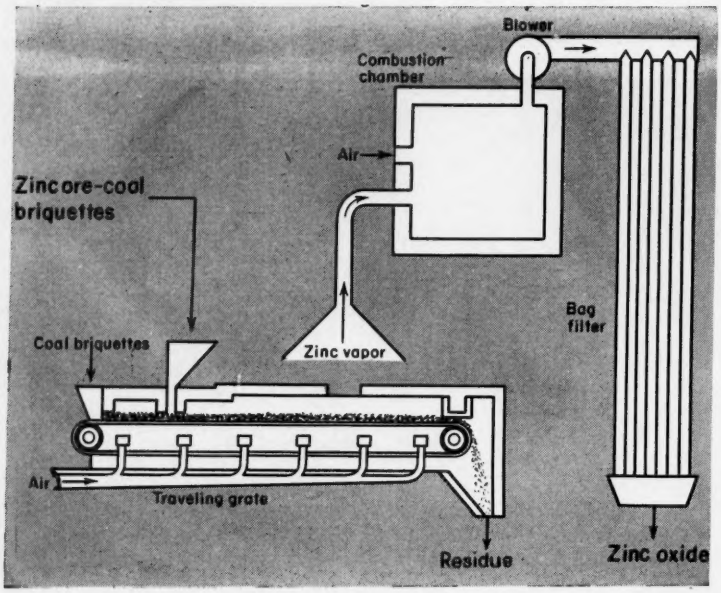


ZnO Made the Modern Way

Continuous traveling-grate furnace eliminates old-fashioned batch, manual operations at New Jersey Zinc's streamlined zinc oxide plant.

A favorite target of New Jersey Zinc's current, mammoth and exceptionally fertile modernization program* has been its veteran American process zinc oxide plant at Palmerton, Pa. Now, as a result, that installation has been converted to a fully continuous and automatic operation.

Primary credit for this engineering advance goes to the traveling-grate furnaces developed by N. J. Zinc engineers. For these units, the company reports, have now completely replaced the conventional, stationary-grate Wetherill furnaces which once formed the heart of the process at Palmerton.

As yet N. J. Zinc is the only outfit in the business using this furnace design. But some observers feel certain that the traveling grate's advantages cannot long be ignored by the rest of the industry.

▶**Beats Back-Breaking Labor**—Chief value of the new unit over the older furnace is readily apparent to anyone who's seen both in operation. For the new design eliminates the back-breaking, batch operation of manually charging and discharging Wetherills, with attendant high labor and maintenance costs and tough operational control.

Instead, briquettes of coal and ore feed continuously and automatically through hoppers onto the moving grate to be carried into the furnace. Zinc vapor evolved there is oxidized in a combustion chamber, sucked through a cold air stream and collected in bag filters.

Easier operational control springs largely from the ease of regulating feed on the traveling grate. For, as N.J. Zinc points out, it's pretty tough to exercise close control over an operator's shovel.

▶**Recent Improvement**—Though developed and put into limited use over three decades ago, the traveling-grate furnace completed its commercial sweep at N.J. Zinc about five years ago. Furnace's adoption, reports a company spokesman, was spurred by a packet of recently incorporated design features.

A key feature is a redesigned combustion chamber which oxidizes zinc vapor evolved from the ore in the furnace. Formerly the oxidation took place in the furnace proper and in heads above it. Details of the combustor are bundled under company wraps right now. But the company reveals that the new design markedly improved control over zinc oxide particle size, shape and purity.

Other design improvements: A larger grate area permits shallower feed beds on grate, and a new mechanical residue-handling system provides automatic waste discharging. Too, hot-exhaust-fan capacity and filter-bag area have been expanded in the newest furnaces.

▶**How Process Works**—About 80% roasted zinc concentrates and 20% fine anthracite are mixed, then fed to Chilean mills. Sulfite liquor binder is added to prepare the mix for briquetting in a roll-type press.

Briquettes, once screened to remove fines, are dried in a direct-fired dryer. Coal briquettes are prepared similarly.

▶**Traveling Grate**—Coal briquettes drop from a hopper onto the cast-iron traveling grate and are spread in a 6-in.-deep even layer. As the grate advances into the furnace, an air stream from beneath the grate ignites the coal.

Then a 6-in.-deep layer of ore-coal briquettes from a second hopper is spread evenly over the burning coal, and the charge passes into the furnace's reduction zone. There the zinc oxide in the ore is reduced and produces zinc vapor. Residue discharges at the end of the grate through a funnel to a moving belt traveling to waste.

▶**Combustion Chamber**—Zinc

* In less than 10 years N. J. Zinc has spent over $50 million on a wide variety of striking and successful projects. For another see *Chem. Eng.*, Aug. 1956, pp. 134-136.

...more

POWELL VALVES

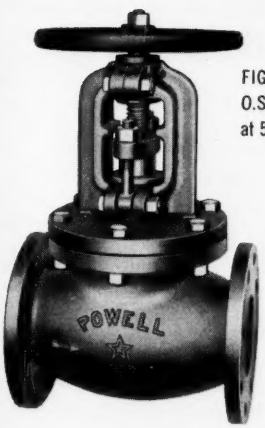
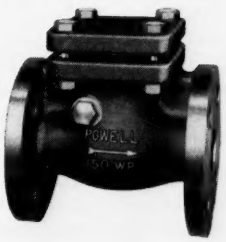


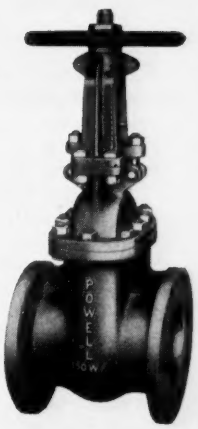
FIG. 2429—Large Size Stainless Steel O.S.&Y. Globe Valve for 150 Pounds W.P. at 500 F. or 230 W.P. at 100 F.

FIG. 1314A—1500-Pound Integral Bonnet Stainless Steel "Y" Valve.

FIG. 2453SG—Stainless Steel O.S.&Y. Gate Valve for 150 Pounds W.P.

FIG. 2342—Stainless Steel Bolted Cap Swing Check Valve for 150 Pounds W.P.





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XUM

vapor and combustion gases feed to the combustion chamber. There, air, under suitably controlled conditions, oxidizes the zinc vapor. Zinc oxide fume, entrained in the gas stream, is sucked through a pipeline with cooling air and feeds to the baghouse.

In the baghouse, zinc oxide powder is filtered from the gas stream and collected in asbestos-muslin bag filters. Some oxide is merely screened before going to market. Some is reheated in a rotary kiln to modify color and brightness, particle size and surface. In some instances finished oxide is pelleted to ease handling and reduce dusting.

Research Centers to Get Particle Accelerators

Basic research at four institutions in the U. S. will take a big step forward with the addition of particle accelerators at Princeton University (Princeton, N. J.), Stanford Research Institute (Menlo Park, Calif.), U. S. Army Ordnance Corps' Redstone Arsenal (Huntsville, Ala.) and Bell Telephone Labs (Whippany, N. J.).

Redstone Arsenal will get a 2-million-volt Van de Graaff particle accelerator for fundamental research related to guided missiles and rockets. Bell Labs will use a 3-mev. Van de Graaff machine as a high-intensity electron-beam source.

Stanford Research Institute is expanding its radiation research facilities with a 1-mev. resonant-transformer electron-beam generator, scheduled for delivery by midyear. SRI scientists will apply it to studying polymerization, initiation of chemical chain reactions and effects of radiation on materials, instruments, equipment, plastics and food products. Design of the new generator allows applying high radiation doses to large work areas. Area that can be covered through the generator's scanning-beam tube ranges from 20 up to 100 sq. in.

▶ **Gets Three-Bev. Synchrotron** —Princeton's James Forrestal Research Center is slated to be the site of a 3-billion-volt, high-intensity synchrotron, to be administered jointly by Princeton and the University of Pennsylvania.

Synchrotron will be financed largely by U. S. Atomic Energy Commission and will be used for unclassified research directed solely toward increasing the basic knowledge of matter.

New machine will be comparable in size to Brookhaven National Laboratory's 3-bev. Cosmotron. It will have an energy equal to that of the Brookhaven accelerator but only one-half that of University of California's Bevatron.

Designed to produce at least 50 times the proton current now available from existing accelerators, the Princeton-Pennsylvania synchrotron will have a much greater beam intensity than either the Cosmotron or the Bevatron. It's expected to generate heavy mesons in much larger quantities than has been possible before.

The accelerator will be available for use by others engaged in very-high-energy physics research.

Synthetic-Fiber Paper On the Way to Market

Within a few months, expect to hear about commercial production of paper made from synthetic fibers.

Actually, the "paper," pioneered by DuPont, is nonwoven, paper-like material, ranging from drapable fabric and felt-like structures to crisp papers or tough parchments. Already, fibers are being made available to the paper industry in semicommercial quantities.

Although some production problems still remain, the toughest ones were solved sooner than expected. Du Pont recently developed specially treated paper-making fibers from nylon, Dacron and Orlon and a special cutting technique.

Paper from synthetic fibers, says DuPont, shows good resistance to corrosive chemicals, bacteria, heat and moisture, as well as high strength, good dimensional stability and dielectric properties.

Potential markets are: Apparel and home furnishings, electrical insulation, map and chart paper, auto panels, shoe fabrics and filtration accessories.

Specialty paper from synthetic fibers will cost more than conventional paper, but Du Pont expects it to compete in applications where their properties offer specific advantages.

South Africa Is Site for Fertilizer, Vanadium

South African affiliate of Fisons Ltd. will build a $5.6-million fertilizer plant at Sasolburg, Orange Free State, to meet growing requirements of farming districts there and in the Transvaal.

Plant, to produce about 200,000 tons/yr. of superphosphate, will adjoin the oil-from-coal plant of Sasol (South African Coal, Oil and Gas Corp.).

Minerals Engineering, Grand Junction, Colo., in a venture with British steel interests and a New York financing firm, has formed a firm called Minerals Engineering of South Africa, Ltd., to develop and mill vanadium deposits in South Africa.

Deposits, says ME, contain enough ore reserves to give over 50 million lb. of recoverable vanadium. Initial capacity of mill will be about 400 tons per day.

Thermal Diffusion May Win Atomic Metals

Although it has to await results of tests now under way, next use for promising thermal diffusion process is likely to be in separating salt mixtures obtained from metallic ores—possibly in producing zirconium and other hard-to-win metals required in atomic power generation.

Chemical engineers at the University of Tennessee, under a one-year research contract from Union Carbide Nuclear Co., are now testing out the process on common salts.

Thermal diffusion process is based on the fact that circulating a liquid (or gas) between hot and cold walls will pull apart certain hard-to-separate products within the liquid. Process

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Basic raw materials for DETERGENTS that get clothes cleaner—faster!

As every housewife knows . . . getting clothes (or dishes or anything) bright and clean isn't half the chore it used to be before she started using today's super-cleaning detergents.

And vital ingredients in the manufacture of these new detergents are Enjay Tridecyl and Ethyl Alcohols and Enjay Tripropylene and Tetrapropylene. Other petrochemicals from Enjay—one of the world's foremost suppliers—play an important role in the manufacture of many other exciting new products for modern living.

The facilities of the famous Enjay Laboratories have just been enlarged to better serve you . . . in finding new ways that Enjay petrochemicals can help you. Call or write for additional information.

Enjay offers a widely diversified line of petrochemicals for industry:

ALCOHOLS & SOLVENTS: Lower Alcohols, Oxo Alcohols, Ketones and Solvents; OIL & FUEL IMPROVERS: Detergent-Inhibitors, V-I Improvers, Oxidation Inhibitors; CHEMICAL RAW MATERIALS: Olefins, Diolefins, Aromatics; ENJAY BUTYL RUBBER & VISTANEX.

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has been used in industry only for separating nonmetallic materials to get such products as solvents, dyeing needs and pharmaceutical compounds.

Researchers at Tennessee will use radically new horizontal column (instead of standard vertical one) developed by Prof. S. H. Jury. Jury's column is expected to be more effective in thermal diffusion work.

Four Firms, University Form New Partnership

Attesting to the trend toward more research in the chemical process industries, State University of New York's College of Forestry and four industrial firms have teamed up to create the Cellulose Research Institute at Syracuse, N. Y.

Institute will probe into such things as wood and fiber technology, plant physiology, wood chemistry, pulp and paper chemistry and polymer chemistry. All research results will be published.

Industry "charter members" of the institute are American Viscose Corp., Buckeye Cellulose Corp., Celanese Corp. and Hercules Powder Co. Membership is open to all companies interested in cellulose research; conferences, seminars and forums will be open to participating members and other scientists.

Institute director will be J. J. Hermans, formerly director of the laboratory for inorganic and physical chemistry at the University of Leiden in the Netherlands.

AEC Maps New Projects: Two Reactors, Ore Mine

U. S. Atomic Energy Commission recently gave the go-ahead on three nuclear power projects.

Argonne National Laboratory will design and operate an $8.5-million experimental nuclear reactor unit for development work on boiling-water reactors. Unit is expected to be operating by late 1959. Boiling water reactor generates steam in the core rather than in a secondary heat-transfer system, but the planned reactor will include heat exchangers.

Hanford Works at Richland, Wash., is authorized $700,000 during 1957 to begin a plutonium-recycle program aimed at developing practical, low-cost methods to fabricate plutonium fuel elements and to test and reprocess the elements in a small reactor. General Electric Co. will carry out the development work.

Uranium purchase contract was recently signed with Homestead-New Mexico Partners for an $8-million project that includes plans for a 750-ton/day uranium mill; 4,500 tons of uranium ore will be stockpiled by the time the mill is ready for operation in February 1958. Western Knapp Engineering Co., San Francisco, started breaking ground for the mill last month, in New Mexico's Ambrosia Lake district.

Oilmen Seek Adequate Depletion for Shale

Oil companies pioneering in extracting oil from shale are seeking a depletion allowance more in line with that of petroleum, aim ultimately at petroleum's 27½% allowance.

Shale in its rock state now qualifies for a 5% depletion allowance, but shale oil backers say exploitation won't be competitive until more depletion is allowed. They're urging 15% as a starter.

Reserves of potential shale oil in Colorado and Utah alone are estimated at about 90 billion bbl. —almost three times today's proven U. S. crude petroleum reserves.

Dow's New Synthetic Fiber Is Unique "Nitrile Alloy"

Advantages of Zefran, Dow Chemical Co.'s new synthetic textile fiber, result from its unique alloy structure, according to a recent disclosure by Dow's textile fiber research director, G. W. Stanton.

Stanton described the alloy structure as "essentially a continuous polyacrylonitrile backbone which is hydrophobic, containing discrete areas of hydrophilic, dye-receptive polymer." Close packing of the hydrophilic groups gives the right cohesive energy density for tightly complexing dye molecules. Acrylics, although having the same constituents, don't provide the same energy density.

Structural differences show up in dyeability. Vat, naphthol and sulfur dyestuffs show excellent buildup on Zefran alloy and poor buildup on ordinary acrylic copolymers.

New fiber has passed textile tests with flying colors and is slated for commercial production soon.

News Briefs

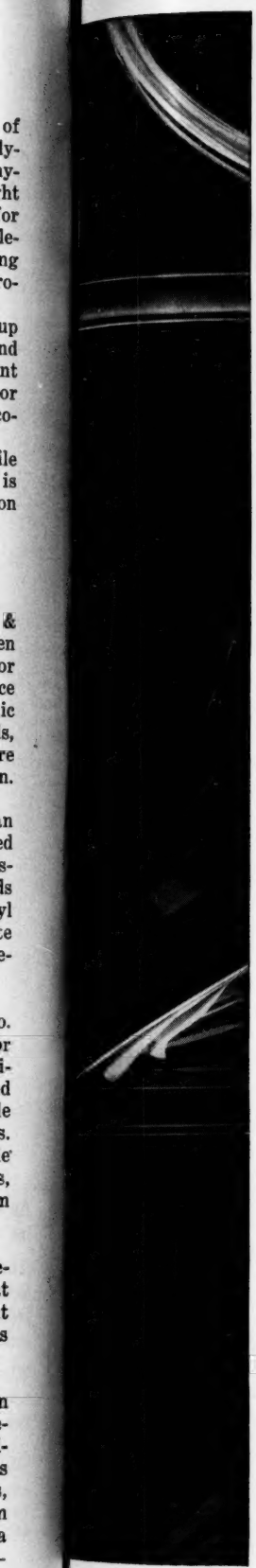
Organotin chemicals: Metal & Thermit Corp. has broken ground at Carrollton, Ky., for a $3-million plant to produce organotin chemicals. Organic compounds of other metals, such as zinc and cadmium, are slated for future production.

Fatty-acid methyl esters: Stepan Chemical Co. has just started up a $400,000 plant in Millsdale, Ill., to produce upwards of 5 million lb./yr. of methyl laurate, stearate, palmitate and myristate. Process is Stepan's own design.

Titanium: Stauffer Chemical Co. has revealed a new process for producing titanium metal. Titanium sponge is produced from titanium tetrachloride via titanium subchlorides. New proces may be feasible for production of other metals, such as columbium, tantalum and zirconium.

Polystyrene: Asahi-Dow has begun producing polystyrene at its new Kawasaki plant. Plant went on stream two weeks ahead of schedule.

Nickel, cobalt: Cuban American Nickel Co., subsidiary of Freeport Sulphur Co., is channeling $100 million for facilities to produce, via a new process, nickel and cobalt metals from Freeport's ore deposits at Moa Bay, Cuba. Hoped-for on-stream date: 1959.



HAVE YOU PIGEONHOLED THE PLURONICS?

To set the PLURONIC block-polymers aside for future evaluation could be a costly mistake. Here's why:

It's like passing up 4-wheel brakes, automatic transmissions, or power steering in the automobile industry.

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Various grades of the PLURONIC® series are already being used to advantage in formulated detergents — as well as a wide range of other products, from alkaline metal cleaners to polyurethane foams.

Here are some characteristics of the many PLURONIC grades that might be advantageous to you: defoaming, dispersing and suspending, sequestering, wetting and penetrating, lubricating, dedusting, free rinsing, low toxicity, plasticizing, wide range of molecular weights (1,000-11,000), chemical stability — to name a few. And they come in a wide choice of physical forms — liquid, paste, flake, and cast-solid. Each PLURONIC grade is 100% active and contains no diluents or fillers.

How can you tell if the PLURONIC block-polymers will benefit you? It's easy . . . just define your problem and, if it calls for any of the PLURONIC characteristics, consult our PLURONIC Grid. The Grid enables you to greatly simplify formulating and processing; suggests in advance the characteristics you can get by using a PLURONIC or combination of PLURONICS in a formulation or process . . . predetermining the performance of the end product itself.

This *pencil-o-metric evaluation** is a new concept in the application of a chemical to product development, making it easy to formulate end products with optimum characteristics . . . products with studied advantages. These block-polymers, therefore, may be the key to progressive formulating that will open up new avenues of progress for your company. *But only a thorough evaluation can give you the full scope of the* PLURONICS' *benefits.*

Write for your copy of the Grid, technical data, and PLURONIC samples . . . or call your nearest Wyandotte representative. If you give us as much background data as possible on your proposed application, we will give you all the available pertinent information to assist you.

**Pencil-o-metric evaluation* is the ability to predetermine the performance of a chemical raw material in a formulation or process prior to actual laboratory study.

MICHIGAN ALKALI DIVISION

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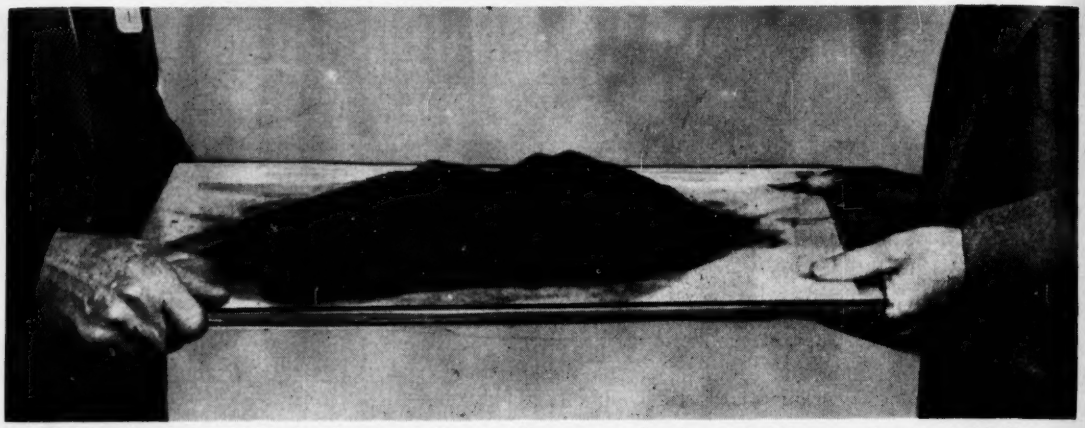
XUM



PLANT'S DAILY OUTPUT of elemental B-10, valuable neutron absorber, is 2.8 lb.—worth at least $3,900.

B-10 Plant Invites Non-AEC Customers

Atomic Energy Commission now wants to share output of its newly revealed boron isotope separation plant with privately-owned atomic industry.

Boron-10, five times better than natural boron for absorbing thermal neutrons, is now available to private industry at prices ranging from $3.10 to $8.60/g., covering assays from 61% to 95%. Atomic Energy Commission, having revealed that its Hooker-Electrochemical-operated plant in Niagara Falls is an isotope separation unit aimed at B-10, wants to start sharing output with non-AEC consumers.

The broader availabilty of B-10, for which there is no other full-scale producing plant in the country, will allow much broader exploitation of its excellent neutron-absorbing property. To date, boron use has been limited to control rods. As an absorber, they control density of the neutrons which bombard atoms to cause fission within nuclear reactors. The rods thus control the amount of atomic energy released. Steel, carbon or other materials act as a carrying agent for very small particles of boron-10 which provide the absorbing property.

Now B-10 use may be extended to include reactor shielding, i. e. protection of personnel from radiation. Lead or concrete structures have been serving the purpose. A given thickness of B-10 is 20 times more effective than lead, 500 times better than concrete. Smaller, lighter reactor housings would be particularly valuable in mobile nuclear reactor power plants for locomotives, submarines, aircraft or even automobiles. However, some lead or concrete would still be required for the ease with which they stop gamma rays on which B-10 has no effect.

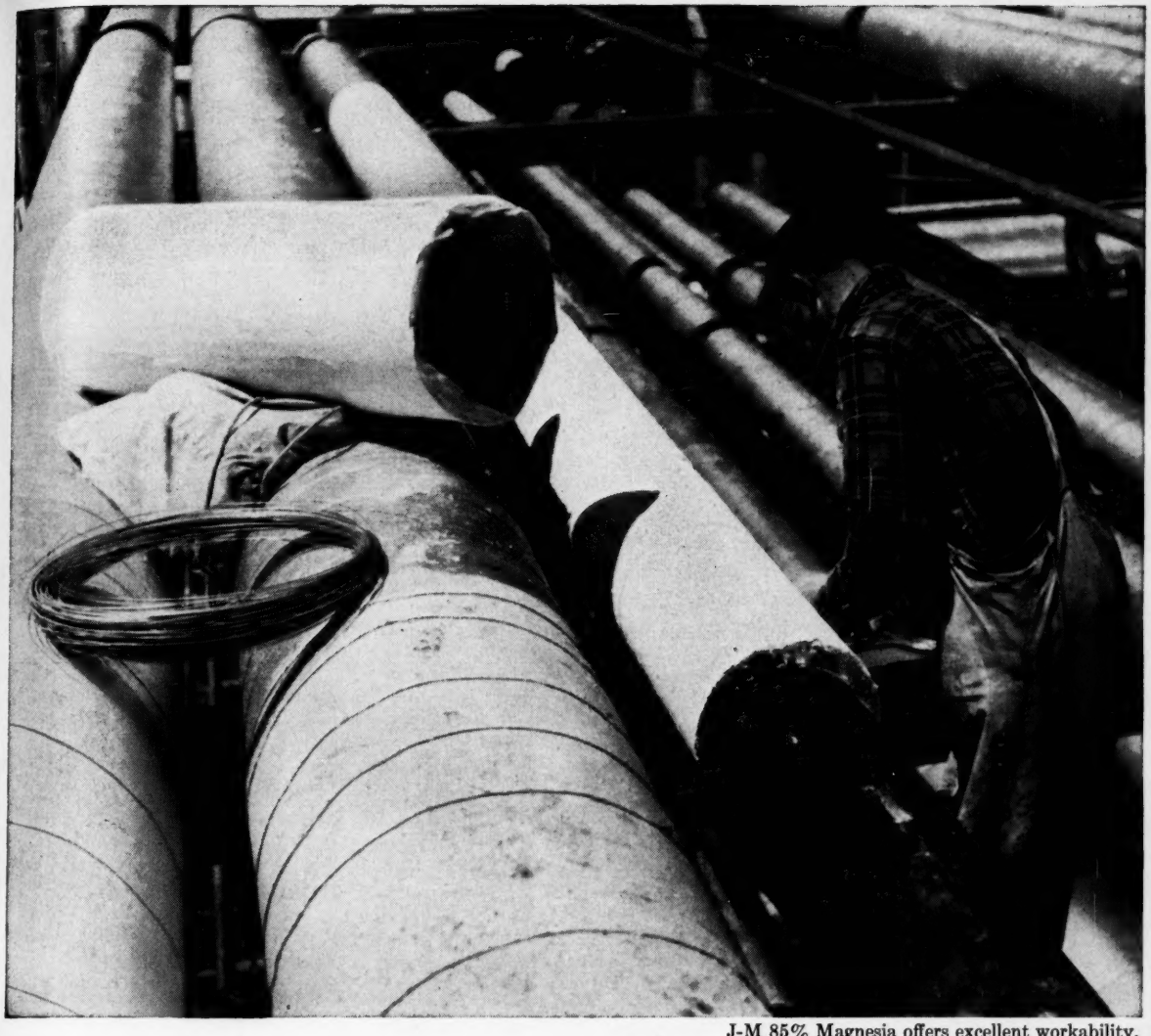
Instrumentation is another field in which B-10 has already shown potential. At Argonne National Laboratory's new boiling-water reactor in Lemont, Ill., a variety of instruments used to measure neutron densities have B-10-coated chambers filled with argon.

Some work has been done on incorporating boron-10 in an important safety device called a dosimeter. Carried on the person of workers in potentially radioactive areas, it measures the amount of radioactivity possibly being absorbed by the individual.

There is a real future likelihood that B-10 will be dispersed as fillers in plastics or paper, or other carrying agents, to fill specialized shielding needs.

In nature, isotopes boron-10 and boron-11 occur as a mixture with boron-10 making up about 19.6%. In the course of their separation at Niagara Falls (see p. 148), boron-10 in the form of dimethyl ether-boron trifluoride complex and potassium fluoroborate are also produced. These are on sale at prices of $1.25 to $5.65/g. B-10 for KBF_4 covering the 61% to 95% assay range and 85¢ to $5.30/g. B-10 for the complex.

Coming off at what is now



J-M 85% Magnesia offers excellent workability, ease of application, accurate temperature control.

Make your next maintenance job less costly...yet measurably more effective...with Johns-Manville 85% Magnesia!

At temperatures to 600F, no insulation is so widely used, or so closely associated with economy and increased operating efficiency as 85% Magnesia. Any wonder, then, that 71% of insulation maintenance engineers responding in a recent survey made 85% Magnesia their first choice in its temperature range.

There's good reason for this overwhelming acceptance. In petroleum maintenance, for example, the material's durability, low conductivity, and structural strength are particularly advantageous in both initial application and during operation.

Lightweight and readily workable, J-M 85% Magnesia assures fast, easy application. In operation it provides the ultimate in insulating value—long life—virtually no replacement—and the very minimum of maintenance.

To assure you maximum value in insulation application, Johns-Manville offers you complete planning and job-site service . . . practical recommendations by the world's most experienced insulation engineers . . . plus expert installation by Johns-Manville Insulation Contractors.

Write today for further information on Johns-Manville 85% Magnesia Insulation. Address Johns-Manville, Box 14, New York 16, N. Y. In Canada, 565 Lakeshore Road East, Port Credit, Ontario.

JOHNS-MANVILLE JM PRODUCTS

Johns-Manville INSULATIONS FOR LASTING THERMAL EFFICIENCY

MATERIALS • ENGINEERING • APPLICATION

Newsworthy chemicals this month

More boron-10 uses promised.....176A
Isopropylbiphenyl cools nuclear reactors..178A
Improved styrene-acrylonitrile copolymer.178B
Thixotropic agent controls polyester flow.178C
Better stabilization, extension for GRS...180A
Zirconium now comes in platelet form....182A
Terpene oxides for intermediate uses....182B
Add conductivity to silicone rubber assets.182C
Diamond hardness bows to new synthetic.184A
Urethane ingredient is non-toxic.....184B
Plasticizer helps vinyls resist cold.....184C
Nitrogen 15 available to 95% enrichment.184D

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the waste end of the process stream is DME-BF_3 complex with a boron content of 10 to 12% B-10 and 88 to 90% B-11. AEC would also like to find markets for this.

And elemental B-11, itself, could be produced with relative ease at the Niagara Falls plant. While B-10 is extremely absorbent when it comes to neutrons, B-11 is extremely transparent. AEC believes that applications may be developed on the basis of this property.

B-10, which is not radioactive, is shipped in polyethylene bags placed within one-gallon tin cans.—**U. S. Atomic Energy Commission, Box 338, Niagara Falls, N. Y.** 176A

Isopropylbiphenyl

Coolant-moderator for nuclear reactors.

Isopropylbiphenyl, newest commercial derivative of biphenyl, now is available in pilot plant quantities. A product of research on new fluids for heat exchange, the chemical recently was reported to offer important economic advantages as a coolant-moderator for nuclear reactors.

It has been used with success in a test "loop" which the company built and installed in the Brookhaven National Laboratories' nuclear reactor pile at Upton, N. Y.

The first reactor designed to use a chemical such as isopropylbiphenyl as a coolant-moderator now is being built for the Atomic Energy Commission at the National Reactor Testing Station, Arco, Idaho.

Isopropylbiphenyl is a water white liquid with a flash point of 139 C., fire point of 152 C.—**Monsanto Chemical Co., St. Louis, Mo.** 178A

Styrene-Acrylonitrile

Improved copolymer with good balance of physical properties.

Full-scale commercial production of Styrex 767, a Dow plastic material based on styrene and acrylonitrile, has been announced. A rigid thermoplastic which can be readily molded or extruded into various shapes and forms, it is an improved copolymer with an excellent balance of physical properties, high degree of toughness and high degree of heat resistance.

Styrex 767 is resistant to acids, bases, salts, oils, waxes, soaps, food stains and many solvents, including gasoline and kerosene. It provides a high degree of clarity in transparent colors, can be produced in a broad range of opaque colors as well.

It is expected to find use for such varied items as tumblers, rigid food containers, cutlery handles, dentures, bristles, refrigerator parts, aerosol nozzles.—**Dow Chemical Co., Midland, Mich.** 178B

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Reader Service

postcard inside the back cover

Thixotropic Agent

Inhibits crawling sag, draining in polyesters.

A new thixotropic agent effectively controls flow properties of polyesters designed for coating, impregnating and other applications.

The addition of as little as 0.2% of the compound, based on the polyester resin, completely eliminates the "crawling" or "cratering" action frequently observed with polyesters. It imparts sag-resistance to an outstanding degree, suspends any pigment and filler present, and produces a significant increase in thixotropic viscosity.

A non-toxic, non-discoloring chemical derivative of castor oil, it is supplied as a finely divided powder. Called Thixcin E, the new additive is characterized by easy stir-in, with maximum results attained at temperatures in the area of 90 F. to 110 F.—**Baker Castor Oil Co., 120 Broadway, New York, N. Y.** 178C

A PROGRESS REPORT...

Architect's drawing of new pentaerythritol plant at Fords, N.J.

more PENTEK®

to meet industry's growing demands

A new plant—with an annual capacity of 25,000,000 pounds—will be on stream this summer—turning out Heyden Newport's full line of Pentek® brand pentaerythritols.

This marks the fourth major expansion of its pentaerythritol manufacturing facilities since Heyden developed the first commercial production of Pentek some twenty years ago. It maintains Heyden Newport's position as the world's leading producer of this versatile polyol.

• • •

A major producer of organic chemicals for a wide diversity of fields, Heyden Newport assures you of a dependable source of quality products meeting modern industries' most exacting requirements.

Our sales and technical staffs are at your service—convenient distribution points make stocks readily available to you.

Heyden Newport divisions serving the process industries:

NEWPORT INDUSTRIES COMPANY
producers of naval stores, tall oil fatty acids, and fine chemicals derived from wood.

NUODEX PRODUCTS COMPANY
manufacturers of additives and special purpose chemicals for paints, plastics, textiles, paper and metal plating industries.

HEYDEN NEWPORT

HEYDEN NEWPORT CHEMICAL CORPORATION

342 Madison Avenue—New York 17, New York

NEW STABILIZING system combats stickiness of raw GR-S in storage.

GR-S Versatility Extended

Related developments in oil-extension and stabilization promise to widen the use and lower the cost of butadiene-styrene rubbers.

Recent research by Shell Development Corp. in the field of butadiene-styrene rubber has led to:

- A magnesium-based stabilizing system which promises to reduce oxidative degradation of oil-extended rubbers substantially.
- A new nonstaining, light-colored extending oil which Shell Oil Co. recently started to market as Dutrex 33.

One of the major problems in the synthetic rubber industry has been oxidative degradation of the raw butadiene-styrene polymers in the presence of transition metal ions (iron, copper, manganese) prior to vulcanization. Aromatic extending oils in particular promote degradation which may occur when the master batch is stored for long periods in warm warehouses, exported to warm climes, left too long in the copolymer dryer, or dried at too high a temperature.

▶ **Mg-Based Stabilization System**—Shell Development, however, has found that addition of small amounts of magnesium naphthenates or resinates to the extending oil prior to emulsification and coagulation of the latex-oil blend stabilizes the masterbatch efficiently, quickly and cheaply. Typically oil-extended butadiene-styrene rubber loses 25% of its initial Mooney viscosity after just 24 hr. at 60 C. Rubber becomes sticky and hard to handle. With 125-250 ppm. of magnesium in aromatic extended rubbers (500 ppm. in highly aromatic extended rubbers), however, it takes 8 days for the viscosity to drop 25%.

Older methods of retarding degradation involve use of low-iron polymerization recipes for the base polymer or of additives in the masterbatch to inhibit the iron-instigated free radical chain reaction. Present additives, however, are rather costly and not generally effective. One additive now undergoing evaluation, Crown Zellerbach Corp.'s beta-conidendrol, would cost about $1.50/lb. in large-scale production. Other possible additives include a number of chelating agents, such as Dow's Versenes (particularly the tetra sodium salt of EDTA which sells for 48-57¢/lb.).

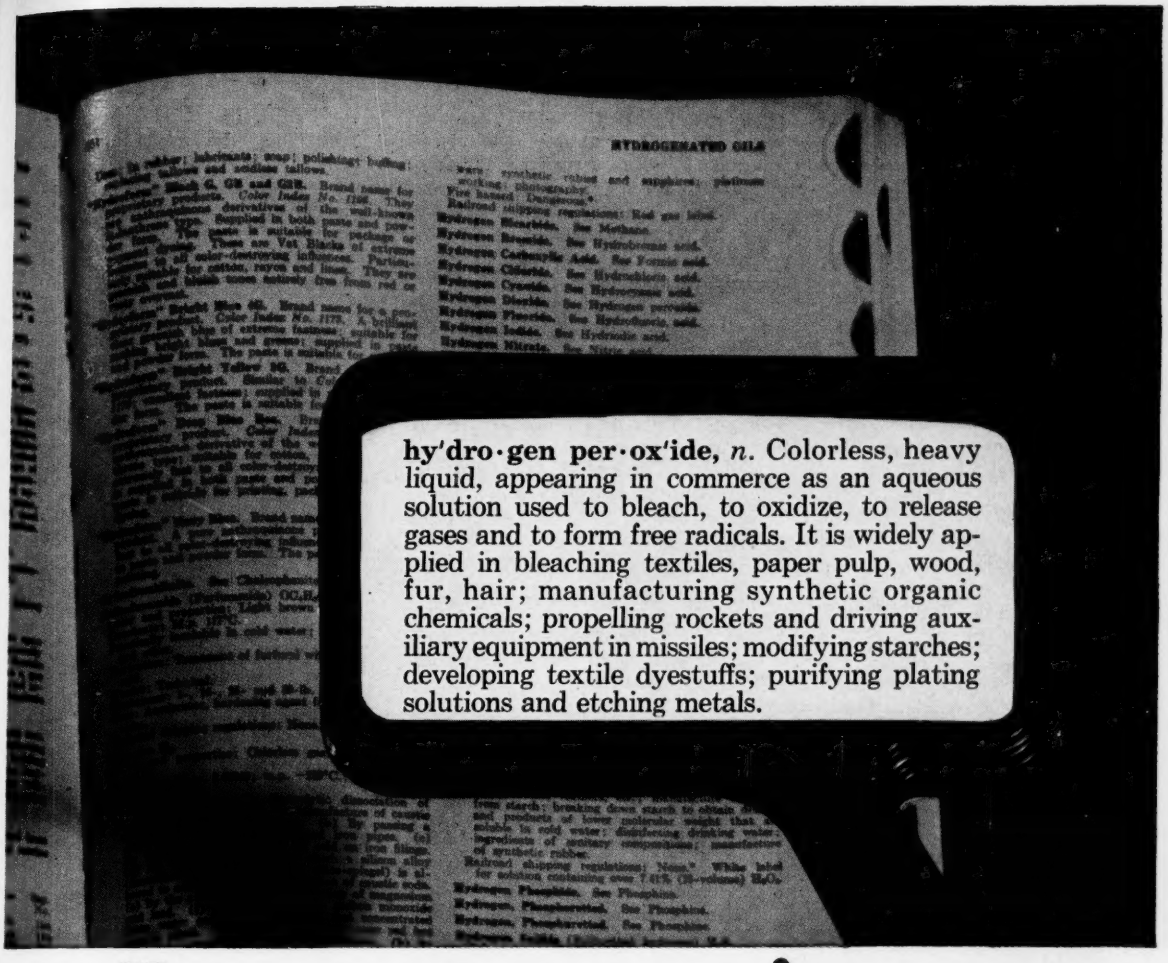
Shell's new system would permit preparation of the additive by on-the-site mixing of magnesium oxide and tall oil or resin acids. Direct addition of epsom salts to the coagulating acid would also work but would require far more material to form the necessary soap in the mix.

Major processing problem centers in the acid content of the mix during coagulation. Ideally, the acid should be added to the mix to avoid hydrolysis of the soap. In commercial practice, the acid and rubber streams are mixed continuously. So care has to be taken to control acid flow. But aside from a slight retardation of cure, the additive has no other effect on processing or vulcanizing quality. And since the additive adds to the weight of the finished product, and since rubber is sold on a weight basis, there's essentially no additional cost involved.

Shell Development has applied for a patent on its magnesium-based stabilizing system, will license it to the rubber industry.

▶ **Extending Oil**—The company's new extending oil, Dutrex 33, is a naphthenic product with excellent resistance to discoloration, low volatility and good compatibility. To manufacturers of such products as refrigerator gaskets who must guard against migration of color bodies to enamel, or of white sidewall tire stock, it offers a truly light-stable oil.

Furthermore, it is said that Dutrex 33, unlike most naphthenic oils, has not been de-


HYDROGENATED OILS
hy'dro·gen per·ox'ide, n. Colorless, heavy liquid, appearing in commerce as an aqueous solution used to bleach, to oxidize, to release gases and to form free radicals. It is widely applied in bleaching textiles, paper pulp, wood, fur, hair; manufacturing synthetic organic chemicals; propelling rockets and driving auxiliary equipment in missiles; modifying starches; developing textile dyestuffs; purifying plating solutions and etching metals.

However you use it

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. . . in drums, tank trucks, tank cars
. . . with Technical Service to help you in handling, storage, process applications.

Soda Ash • Caustic Soda • Calcium Chloride
Chlorine • Potassium Carbonate • Sodium Bicarbonate • Caustic Potash • Chloroform
Ammonium Bicarbonate • Cleaning Compounds
Ammonium Chloride • Sodium Nitrite • Aluminum Chloride • Snowflake® Crystals • Methyl Chloride
Monochlorobenzene • Para-dichlorobenzene • Vinyl Chloride • Ortho-dichlorobenzene • Hydrogen Peroxide
Methylene Chloride • Carbon Tetrachloride

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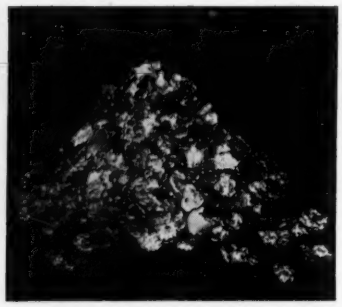
prived of desirable vulcanizate and processing characteristics along with color bodies and color formers removed during manufacture. In fact, it incorporates many of the processing advantages which aromatic and highly aromatic extending oils usually have over conventional naphthenic extenders: greater compatibility; faster blending; the extended rubber softens more readily upon mastication; finished product shows better strength characteristics. Yet it avoids drawbacks to aromatics' use in light stock: They promote oxidative degradation of the uncured masterbatch; they discolor readily, tend to migrate out of the finished product.—**Shell Oil Co., 50 West 50th St., New York, N. Y.** **180A**



Zr Platelets

New form excels sponge in shipping ease.

Zirconium will come in new platelet, as well as conventional sponge, form from U.S. Industrial Chemicals' about-to-be-completed plant in Ashtabula, Ohio. Company is quoting prices of $4.75 to $6.50/lb. for its hafnium-free sponge or platelets, compared to present $12/lb. price for sponge.

Platelets, irregular flakelike pieces about the size of dimes and quarters, are superior to the ordinary sponge form in that they are non-pyrophoric, non-hygroscopic and extremely pure. ICC requires that sponge be shipped in packages of not more than 75 lb., wrapped in polyethylene, blanketed by argon, and packaged in single-trip sealed metal drums. None of these restrictions apply to platelets because they are classified as metal, rather than metal sponge, and they are completely safe to handle. To the zirconium user, platelets are said to provide at least as much processing ease as sponge.

Predicted price reduction is credited to economies of new USI-developed sodium reduction process to be christened by the new plant. Planned plant capacity has recently been raised from 1.5 million to 2 million lb./yr.—**U.S. Industrial Chemicals Co., 99 Park Ave., New York.** **182A**

Terpene Oxides

Novel epoxy compounds suggested for use as intermediates.

Dipentene monoxide and alpha-pinene oxide are now available in laboratory quantities for test purposes, and can be prepared in drum quantities on reasonable notice.

Both are suggested for use as intermediates in organic synthesis, as solvents, as plasticizers for resins such as polyvinyl chloride, and in the manufacture of perfumes, flavorings, pharmaceuticals, protective coatings, insecticides, bactericides, lubricant additives, adhesives and flotation agents.

Dipentene monoxide (d-1-1-methyl-1 2-epoxy-4-isopropenyl-cyclohexane) combines the reactivity of an epoxy group with that of an olefinic double bond in a cyclic terpene molecule. It is a water-insoluble, solvent-soluble colorless liquid of characteristic odor. It undergoes the usual reactions of the epoxy group and the external double bond of the terpene molecule.

Alpha-pinene oxide (d-2,6,6,-trimethyl-2,3-epoxybicyclo 3.1.1 heptane) combines the reactivity of an epoxy group with that of the bicyclic system of alpha-pinene, which causes it to undergo unusual reactions. It is a colorless liquid of camphor-like odor, insoluble in water and soluble in organic solvents. It does not undergo the usual ring-opening reaction of epoxides but rearranges in the presence of a trace of acid. Under aqueous conditions, the rearrangement leads largely to sobrerol; under anhydrous conditions, the product is mainly campholenic aldehyde.—**Becco Chemical Div., Food Machinery & Chemical Corp., Station B, Buffalo, N. Y.** **182B**

Conductive Silicone

Adds electrical conductivity to unique silicone rubber properties.

Compounded with conductive carbon blacks, X-1516 is the first of a new class of silicone rubber compounds different from all others previously available. In addition to all of the desirable properties of conventional silicone rubbers, such as their wide thermal operating limits and well-known release properties, it provides the highest degree of electrical conductivity now commercially available in a flexible, thermosetting material.

Electrical resistivities of less than 100 ohm-cm. are easily obtained. Electrical properties of X-1516 are not significantly affected by mechanical working during processing and are therefore uniform throughout any fabricated product.

By blending it with other silicone rubber compounds, a spectrum of compounds can be obtained whose electrical resistivity can be adjusted to any desired point in the range between 3 x $(10)^1$ and 1 x $(10)^{16}$ ohm-cm.

It is suggested for uses where:

- An electrically conductive

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Reader Service

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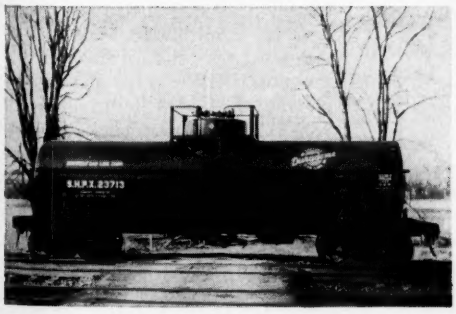
Red-hot recipe for tougher tank cars



Typical DURADOME—designed for formaldehyde service

WHEN heavy-gauge steel is formed and welded into a tank car tank . . . certain internal stresses develop which tend to weaken the metal. That is why ACF tanks are "popped into the oven" to relieve these stresses.

Each tank is scientifically heated under controlled conditions. This results in a tank of uniform strength which is ready to resist the forces of load and impact which occur during transportation.

When you're looking for the toughest tank cars ever built, look to Shippers'. We are the exclusive sales agent of ACF-DURADOME tank cars for industry. You'll find a nationwide network of Shippers' Car Line offices and repair shops ready to serve your transportation needs.

Whatever your tank car requirements may be, better talk to Shippers' . . . and get the benefits of *modern* tank car service!

SHIPPERS' CAR LINE

Division of acf INDUSTRIES, Incorporated
30 Church Street, New York 7, N. Y.

CHICAGO, ILL. • HOUSTON, TEX. • SAN FRANCISCO, CAL. • MILTON, PA. • EAST ST. LOUIS, ILL. • SMACKOVER, ARK. • TULSA, OKLA. • NORTH KANSAS CITY, MO. • RED HOUSE, W. VA.

rubber is required to operate at higher or lower temperatures than are possible with other rubbers.

• High stability of electrical conductivity during processing is required.

• Uniformity of electrical conductivity throughout a product is desired.

• A series of compounds with various electrical conductivities is needed.

• Difficult problems in fine profile extrusion are encountered and electrical conductivity is either required or is unimportant.

• The adhesive properties of silicones are needed in conjunction with electrical conductivity.

It has already found use as a heating blanket in aircraft wings; in hospital tubing.

X-1516 can be fabricated on any equipment currently used by rubber fabricators. It can be molded, extruded or calendered. It requires a minimum of time for replasticizing, and, after catalyzing, need not be freshened again for most molding, extruding or calendering operations.—**Union Carbide & Carbon Corp., Silicones Div., 30 East 42nd St., New York, N. Y.** 182C

Diamond Hardness Bows to Synthetic

For the first time, the world has a substance which compares with diamond in hardness. Cubic boron nitride, recently produced via General Electric's superpressure, supertemperature research, scratches diamond almost exactly as diamond scratches diamond. Never before produced synthetically or naturally, it has polished away the surface of a large diamond at the same rate as diamond powder in actual lapping tests.

But in another important characteristic, it appears to be superior to nature's most glamorous substance. Diamond, being basically carbon, literally burns up in air about 1,600 F. Cubic boron nitride, called borazon by GE, can withstand temperature of more than 3,500 F. and thus should be better for many industrial uses.—General Electric Co., Schenectady, N. Y. 184A

Isocyanate Resin

New urethane ingredient is non-toxic.

An improved isocyanate resin for formulating urethane surface coatings is essentially a monomer-free non-toxic adduct. Called Mondur CB, it replaces the company's Mondur C. While providing the same properties, it eliminates the need for special ventilation and protective masks which are recommended in processing and applying coatings and adhesives containing free toluene-diisocyanate monomer.

Preliminary tests show the new product, when used in conjunction with polyester resins, is equal or superior to Mondur C in work life, drying time, film hardness, solvent and impact resistance.—**Mobay Chemical Co., 1700 South Second St., St. Louis 4, Mo.** 184B

BRIEFS

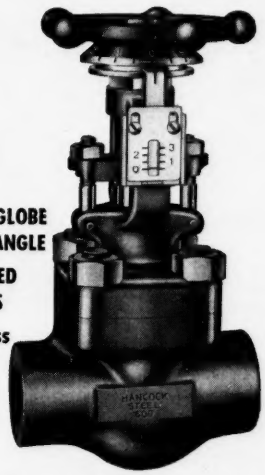
Primary plasticizer, a modified alkyl phthalate, imparts low temperature flexibility in vinyl equivalent to that obtained from n-octyl-n-decyl phthalates. But its cost is lower. Called PX-313, it offers a combination of low temperature flexibility and low volatility with processing characteristics which make it useful for vinyl jacket wire, high quality coated fabrics, sheeting and film. — **Pittsburgh Coke & Chemical Co., Grant Bldg., Pittsburgh, Pa.** 184C

Nitrogen 15 can now be manufactured enriched to above 95%. A stable isotope widely used in research as a tracer, it has been available up until now enriched to a maximum of 60%.—**Isomet Corp., P. O. Box 34, Palisades Park, N. J.** 184D

HANCOCK VALVES

NEW

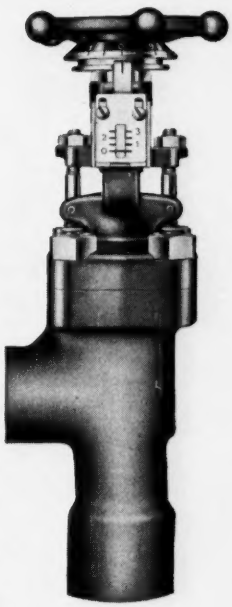
"FLOCONTROL"
TYPE 5525 — 600# GLOBE
TYPE 5535 — 600# ANGLE
RENEWABLE HARD-FACED STAINLESS STEEL SEATS
"500 Brinell" Stainless Steel V-Port Discs.



For general industrial service. Variable orifice, shut-off and index combined in a single valve. Any desired setting can be instantly duplicated. **Sizes:** ¼" thru 2". **Standard Materials:** Forged carbon steel. **Connections:** Screwed, Socket Weld and Flanged Ends. **Screwed and Socket Weld Valves:** For all pressures up to 600 psi at 910°F. O.W.G. — 2000 psi at 100°F. **Flanged Valves:** For all pressures up to 600 psi at 850°F. O.W.G. — 1440 psi at 100°F.

NEW

HI-PRESSURE DROP
TYPE 5505 — 600# ANGLE
INTEGRAL HARD-FACED SEATS
Stainless Steel Tube.



An orifice type valve, with shut-off and index in a single unit that permits the use of a smaller valve with a large capacity. Designed to withstand the terrific wrecking power of continuous blow-down. Also for use on feed-water, by-pass relief, in turbine washing processes, and where erosion is extremely severe. **Size:** 1". **Standard Materials:** Forged carbon steel. **Connections:** Screwed and Socket Weld Ends. For all pressures up to 600 psi at 910°F. O.W.G. — 2000 psi at 100°F. A.S.M.E. maximum boiler pressure 970 psi.

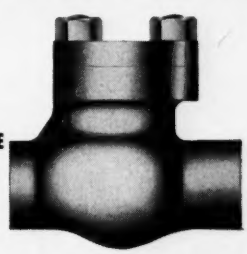
factured. You can be sure of long resistance to wire drawing, galling, steam cutting, erosion and corrosion — for leakproof tightness month after month. They surpass the toughest service demands of process and power piping systems in the most modern refineries, petrochemical, power and industrial plants. A high degree of standardization in all sizes simplifies both maintenance and inventory needs.

Let the durability, performance and economy of Hancock 600# Steel Valves save money for you. Whether you are adding facilities, building a new plant or setting up a revalving program, get all the reasons why these tough valves serve better and longer. Complete information is yours on request.

When Hancocks go in, valve costs go down

NEW

LIFT CHECK VALVE
TYPE 5540 — 600# GLOBE
RENEWABLE HARD-FACED STAINLESS STEEL SEATS
"500 Brinell" Stainless Steel Piston Discs.



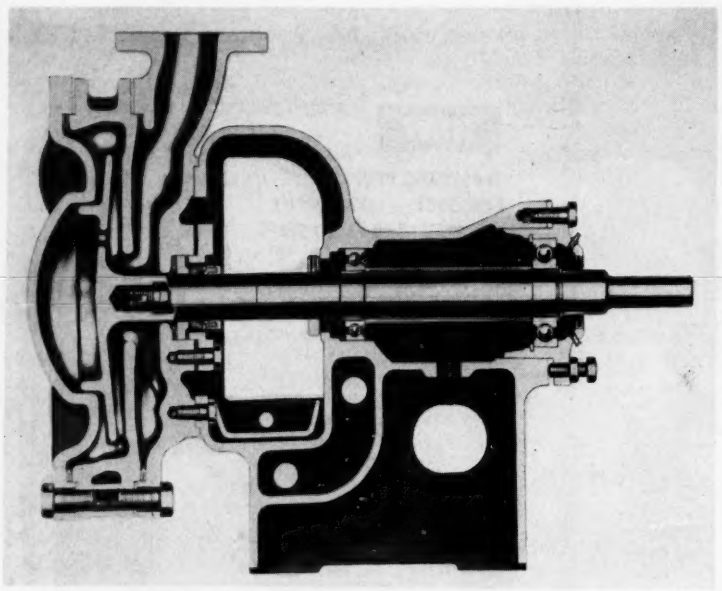
For general industrial service. **Sizes:** ¼" thru 2". **Standard Materials:** Forged carbon steel. **Cap:** Bolted. **Connections:** Screwed, Socket Weld and Flanged Ends. **Screwed and Socket Weld Valves:** For all pressures up to 600 psi at 910°F. O.W.G. — 2000 psi at 100°F. **Flanged Valves:** For all pressures up to 600 psi at 850°F. O.W.G. — 1440 psi at 100°F.

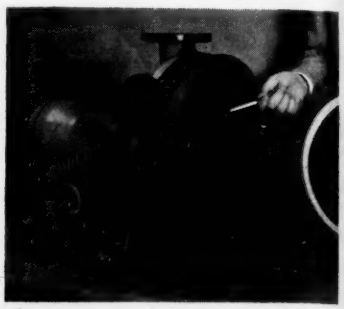
A PRODUCT OF MANNING, MAXWELL & MOORE, INC.

WATERTOWN 72, MASSACHUSETTS

MAKERS OF 'ASHCROFT' GAUGES, 'AMERICAN' INDUSTRIAL INSTRUMENTS, 'CONSOLIDATED' SAFETY AND RELIEF VALVES, 'AMERICAN-MICROSEN' INDUSTRIAL ELECTRONIC INSTRUMENTS, *Stratford, Conn.* 'HANCOCK' VALVES, *Watertown, Mass.* 'CONSOLIDATED' SAFETY RELIEF VALVES, *Tulsa, Okla.* AIRCRAFT CONTROL PRODUCTS, *Danbury, Conn. and Inglewood, California.* "SHAW-BOX" AND 'LOAD LIFTER' CRANES, 'BUDGIT' AND 'LOAD LIFTER' HOISTS AND OTHER LIFTING SPECIALTIES, *Muskegon, Michigan.*

In Canada: Manning, Maxwell & Moore of Canada, Ltd., Galt, Ontario





For the first time, glassed steel has been incorporated successfully in a centrifugal pump for long life under adverse conditions.

One Pump Handles Wide Range of Corrosives

In a combined effort to reduce the cost of pumping corrosive process liquids and slurries, Goulds Pumps, Inc., and Pfaudler Co. have evolved a glassed-steel centrifugal pump.

Extensive field trials indicate the pump can withstand a broad range of severe corrosive conditions and, at the same time, meet the pumping standards of the process industries.

▶**Stays on Line**—All inner surfaces of the pump are glassed so that liquid never contacts metal. Since Pfaudler's glass resists all organic and inorganic acids (except hydrofluoric) and alkalis up to pH 12 at 212 F., there is little chance for corrosion of the pump.

This means the processor can switch the pump from one liquid or slurry to another without need to worry about the corrosion resistance of the pump. Changeover time is cut and no longer is there need to stock different pumps and pump parts to handle specific products, it is said.

▶**Protects Product**—Since the glass is inert, it exerts no catalytic effect on liquid being pumped. It will not react with the material to contaminate the end product.

Many plastic and rubber polymers will cling to metal surfaces, yet they do not stick to glass. Since the internals of the pump remain comparatively clean, the pump may be cleaned with greater ease in less time.

▶**Resists Abuse**—Sharp mechanical impact on the glassed-steel surface will only damage the surface at the point of impact. Interlocking chemical action between metal and glass at the fusion temperature reached during manufacture prevents fractures from running as they do in a window pane or glass desk top.

Normally, these pumps will withstand quick changes in liquid temperature up to at least 200 F. differential and higher, depending on operating conditions.

▶**Why Not Sooner?**—Before this pump could become a reality Pfaudler had to solve a basic problem in glassing steel. After glass is fused to metal at high temperatures, the cooling process releases free hydrogen from the metal.

When only one surface of the metal is glassed, the gas escapes from the unglassed side. In a completely glassed part such as an impeller, the hydrogen must vent through the glass.

Under most conditions, the escaping gas would cause de-

Historically Significant

The LaBour pumps in this picture are relatively new, but they are nevertheless significant of important historical facts. The first LaBour pump was installed by Tennessee Eastman Company in this plant at Kingsport, Tenn. in 1931, and they have purchased a total of more than a hundred additional LaBours at intervals since then.

Most of the LaBour pumps being sold today go to customers like this one, who know from their own experience that LaBour means dependable service with minimum maintenance. And because LaBour was the first commercial producer of a self-priming centrifugal pump, the experience records of many companies go back more than 30 years.

The pumps in the above picture are LaBour's latest packingless type, which of course were unknown in 1931. The consistent performance records of the earlier LaBours, however, warranted the choice of the new ones, just as this whole history warrants your investigation of LaBour pumps for your chemical-handling jobs.

LABOUR

Equipment Developments This Month

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fects in the glass. Pfaudler's success in releasing this gas without damaging the glass made possible the design of this pump.

In addition, methods were developed to control glass thickness where clearance is critical for moving parts. Also, techniques were devised for grinding to precise tolerances the glassed seal joints and impeller shaft.

▶ **Piece by Piece**—To provide the best design for glassed-steel construction, the casing is split into three parts—suction piece, casing and casing cover. All surface partings seal with retained Teflon envelope gaskets against glass.

The semi-open impeller is designed especially for glassing to produce a rotating member without internal joints exposed to process liquid. Hub of the impeller, ground to the correct sealing dimension, extends beyond the sealing zone.

Impeller screws onto the shaft with right-hand threads which tighten against the clockwise rotation of the pump. It is locked in place by a red-fiber insert located in slot on shaft.

On slurry service, impeller will handle solids ranging up to $\frac{1}{16}$-$\frac{3}{4}$ in., depending upon the size of the pump.

With the three-piece construction there is ample flexibility for positioning the flanged suction and discharge connections. Note, that the stuffing box is on the suction side of the impeller. This assures long life for seal or packing since only suction head is exerted on the stuffing box.

For More Information . . .

about any item in this department, circle its code number on the

Reader Service

postcard inside the back cover

The Goulds-Pfaudler centrifugal pump will be built in four sizes for capacities up to 700 gpm. and heads up to 140 ft.—**Goulds Pumps, Inc., Seneca Falls, N. Y.** 188A

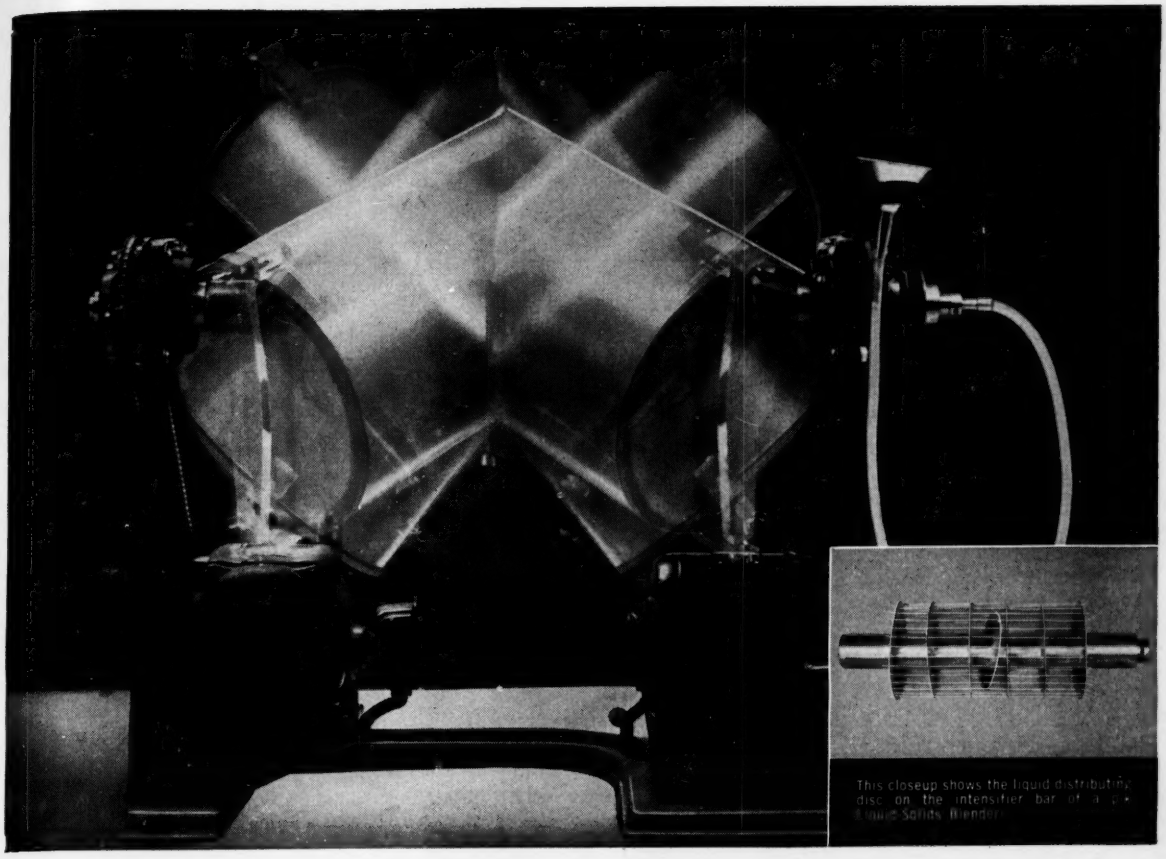
Positive Pump

For dry solvents eliminates priming problems.

Developed to pump dry aromatic liquids or any other petroleum product, the Granco type A pump claims high efficiency. Reason is a unique "universal-joint" action incorporated in the rotary, positive-displacement design.

Self-lubricating nature of the friction-free bearings assures that no lubricants can contaminate the pumped liquid. Mechanical seals prevent leakage through the stuffing box. Other design features enable the pump to withstand years of maintenance-free service.

Available in capacities from 25 to 300 gpm., type A pumps



P-K Liquid-Solids* Blender Creates New Production Concept!

A new, revolutionary method for blending liquids into dry materials is highly successful in practically all chemical and process applications.

Essentially, the p-k Liquid-Solids blender operates in the following manner. Liquids, regardless of viscosity, are introduced into a rapidly revolving bar (by gravity or pump). The liquid is flung outward in a finely divided state from a distributor disc and feeds a continuous fine spray into the tumbling mass of dry materials as the shell rotates. A series of stainless steel wires, strung horizontally along the bar, prevents the formation of agglomerates and further promotes liquid dispersion.

This unique blending operation can be accomplished in *minutes* and eliminates costly, time consuming steps, such as screening, pulverizing and mulling. With the p-k Liquid-Solids blender, you will get a fast, one step operation that guarantees *consistent* blending *uniformity* not otherwise obtainable.

The exclusive p-k dry mechanical seal prevents materials from entering the bearing housing and protects against product contamination. Two vapor and dust-tight quick-opening covers allow easy access to the baffle-free interior for cleaning. The p-k Liquid-Solids blender is available in sizes ranging from 1 to 50 cubic feet working capacity.

*Patented and Patents Pending

Patterson Kelley
Chemical and Process Division

P-K Twin Shell Blenders* • Heat Exchangers • Packaged Pilot Plants • P-K Lever-Lock Doors*

Investigate P-K's Blending Concept

P-K's Customer Service Laboratory will be pleased to test-blend your materials . . . preferably under your supervision. Material formulations will be blended to your exact specifications and returned for analysis, together with a complete report. P-K recommends pre-tests for all "Liquid-Solids" applications, because of the many variables that may affect blending procedures necessary for intimate dispersion of liquids in solids. Our Lab also conducts comparison tests in pilot models of all other basic blender types . . . from ribbon and double cone to p-k's standard Twin Shell and "Intensifier" models.

All of them are members of a growing family of p-k blenders and all are described in our new catalog 14. Write our Mr. R. T. Dotter for your copy . . . and arrange, too, for a pre-test of your materials.

The Patterson-Kelley Co., Inc., 140 Hanson St., East Stroudsburg, Pa.

have thoroughly proven themselves during five years of severe field tests.—**Granberg Corp., 1308-67th St., Oakland 8, Calif.** 190A

Metering Pump

Can be mounted on top of barrel or drum.

A controlled-volume pump added recently to the Milton Roy line is designed for mounting on barrel heads. In this position, the new pump can meter toxic or corrosive chemicals from upright 55-gal. barrels against pressures up to 100 psi.

Driven by constant-speed, ½-hp. motors, this portable barrel pump is available in maximum capacities from 500 ml./hr. to 4 gph. Capacity can be adjusted from zero to maximum. Repetitive pumping accuracy is ±1%.—**Milton Roy Co., 1300 East Mermaid Lane, Philadelphia 18, Pa.** 192A

Carbon Ejector

Either water or steam operated, handles corrosives.

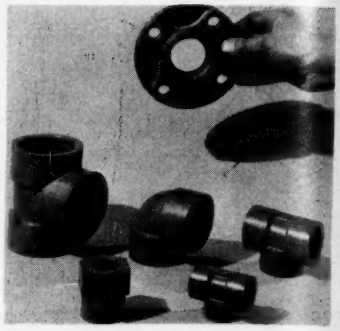
Carbon ejectors using either steam or water as motive fluid now are available to handle all corrosive fluids. They empty tanks of corrosive liquids.

These ejectors are reported exceptionally rugged in both a mechanical and thermal sense. There are no moving parts and the carbon is protected completely by a cast-iron casing.

Motive jet or nozzle pressure required for operation can be as low as 5 psi. Standard size is rated for 5,000 gph. capacity.—**Delanium Graphite Co., 134 Elmora Ave., Elizabeth, N. J.** 192B

Gel Maker Blocks Contamination With Vinyl Pipe

Corrosive liquids are transferred through these 4-in. PVC lines at Reheis Co., Inc., Berkeley Hgts., N. J. without picking up contamination or corroding the pipe. That's why Reheis in its expanded aluminum hydroxide plant has installed some 6,200 linear ft. of 2- to 4-in. pipe and 4,930 fittings made from Goodrich Geon rigid-PVC resin. Flow is controlled by 180 valves with PVC bodies. While the lines utilize cemented socket fittings, flanges at key points permit disassembly of pipeline sections.—Alpha Plastics Co., Livingston, N. J. 192C



Plastic Fittings

Have built-in sealer to eliminate leaks at joints.

A paper-thin layer of plastic on the inside wall of a new pipe fitting promises to eliminate joint leaks in cemented or solvent-welded pipe installations.

Only a few thousandths of an inch thick, the plastic layer makes the inner half of the fitting slightly smaller than the outside diameter of the pipe being joined. But a light coat of solvent-base cement applied to the fitting and the pipe end softens the plastic layer so that the pipe can be pushed snugly into place. High contact pressure between pipe and fitting causes a positive leak proof weld.

Uscoweld styrene-acrylonitrile fittings are now available for standard pipe sizes from ½ to 2 in.—**United States Rubber, 1230 Avenue of the Americas, New York 20, N. Y.** 192D

Check Valve

Withstands corrosive acids and chemicals.

A new rubber-lined horizontal swing-check valve may be used under corrosive conditions in acid and chemical process lines.

Valve body is rubber-lined cast iron or fabricated steel. Trim can be manufactured of any alloy, hard rubber, plastic or Teflon. Manufacturer claims that valve reduces flow only a negligible amount. Available sizes range from 1 to 14 in.—**La Favorite Rubber Co., Wagaraw Rd., Hawthorne, N. J.** 192E

Only Continental offers you

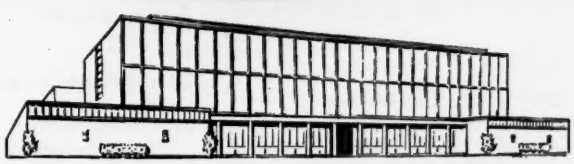
Perma-LINED

steel containers for hard-to-hold products

Your chemical, paint and petroleum products travel with greater safety in Continental's exclusive Perma-Lined steel containers. That's because specially-formulated Perma-Lining enamels are airless hot-sprayed and baked right in the formed container. Every last inch of inside surface—even side and bottom seams—gets complete uniform coverage.

In addition to product protection, Perma-Lined containers give you eye-catching lithography by Continental craftsmen. And, if you ever need research or engineering help, it's available as part of our steel container service.

Let Continental's Perma-Lined containers work for your hard-to-hold products. Call soon.



PERMA-LINED CONTAINERS TO FIT EVERY PRODUCT

Perfected by Continental's Research and Development Center in Chicago—and backed by our vast experience in all types of metal packaging—Perma-Linings are available to fit almost every chemical, paint and petroleum product. Moreover, we are prepared to develop new Perma-Linings for your special use.

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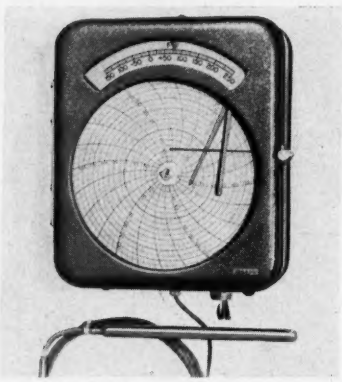


Indicator-Recorder

Can be read with ease from a distance.

To provide easy reading of temperature or pressure from a distance, a large indicating scale and pointer have been incorporated into the standard Minicorder. The new instrument resulting from this combination is called a Mindicorder.

Indicator scale is mounted above the recording chart. For greater reading ease the single door is designed with separate viewing windows. A fluorescent pointer indicates the temperature or pressure that is being recorded on the chart below.

Temperature ranges run from as low as −200 F. up as high as 1,000 F., with pressure units available to as high as 2,000 psi.—**The Dickson Co., 7422 Woodlawn Ave., Chicago 19, Ill. 194A**

Oxygen Indicator

Measures trace quantities in various inert gases.

As little as 2 ppm. of oxygen in hydrogen or inert gases can be measured by a new supersensitive indicator despite the presence of up to 3% carbon monoxide.

Gas being tested passes continuously over a catalyst which causes any oxygen present to combine with hydrogen. The rise in temperature caused by this reaction is measured by an extremely sensitive thermopile. Output voltage from the thermopile is indicated and recorded by a potentiometer or can be fed to controller.

If the gas does not contain enough hydrogen to react with the oxygen, an electrolytic cell built into the indicator generates a small amount and mixes it with the gas sample.—**Baker & Co., Instrument Div., 205 Grant Ave., East Newark, N. J. 194B**

Gas Detector

Warns when cleaning produces dangerous gases.

Initial tests in this country indicate that a West German device can reduce hazard from dangerous gases produced by the interaction of chemical cleaners with residues in process vessels.

Working on much the same principle as hydrogen sulfide detectors now made in this country, the Drager gas detector warns of specific poisonous gases present in air samples drawn through a glass tube by a bellows arrangement. The test is rapid and precise.

Arsine gas commonly produced during chemical cleaning operations usually is mixed with hydrogen sulfide. Arsine detection tubes used with the Drager device are not influenced by the presence of hydrogen sulfide. The same is true for other indicator tubes used with the device.—**Dragerwerk, Lubec, Germany. 194C**

Reaction Control

Accurately controls oxidation-reduction processes.

A convenient way to control oxidation-reduction processes is with the new O-R-P Cell which is sensitive to changes in the relative concentration of specific chemical ingredients in a liquid medium. Such changes affect the electrical potential between the inert-metal electrode and a reference electrode.

Cell operates at pressures up to 35 psi. and may be obtained alone or with a self-balancing potentiometer. The combination in conjunction with electric, electronic or pneumatic controlling devices can regulate either batch or continuous-flow processes.—**Fischer & Porter Co., 2000 Jacksonville Rd., Hatboro, Pa. 194D**

Ultrasonic Flowmeter

Measures accurately without obstructing flow.

A new straight-through flowmeter achieves accurate flow rate measurements by modification of an ultrasonic beam.

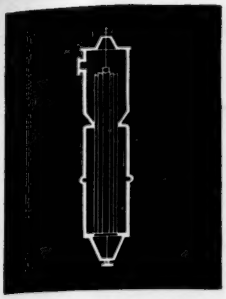
Since this new instrument does not obstruct flow, pressure drop is eliminated, maintenance is easier and greater accuracy is consistently attained. It is reported particularly adapted to measurement of kerosene, liquid oxygen, water and similar liquids.

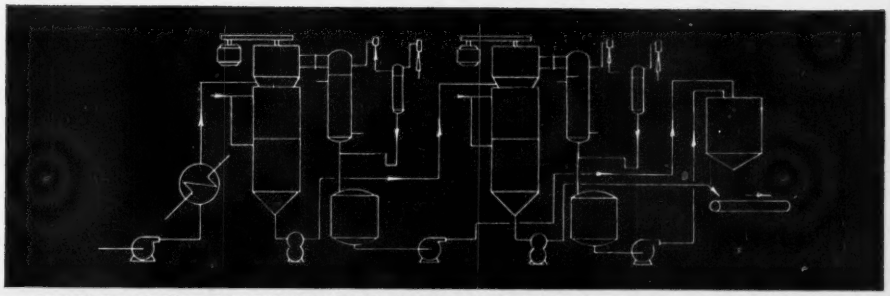
The Glennite meter, model UF-100, will measure rates of 1,000 to 4,000 gpm. with an accuracy better than 1%. It provides 5-v. full-scale output for standard telemetering and recording systems. Special instruments can be provided for volumetric flow and complete control systems can be designed around the flowmeter.—**Gulton Industries, Inc., 212 Durham Ave., Metuchen, N. J. 194E**

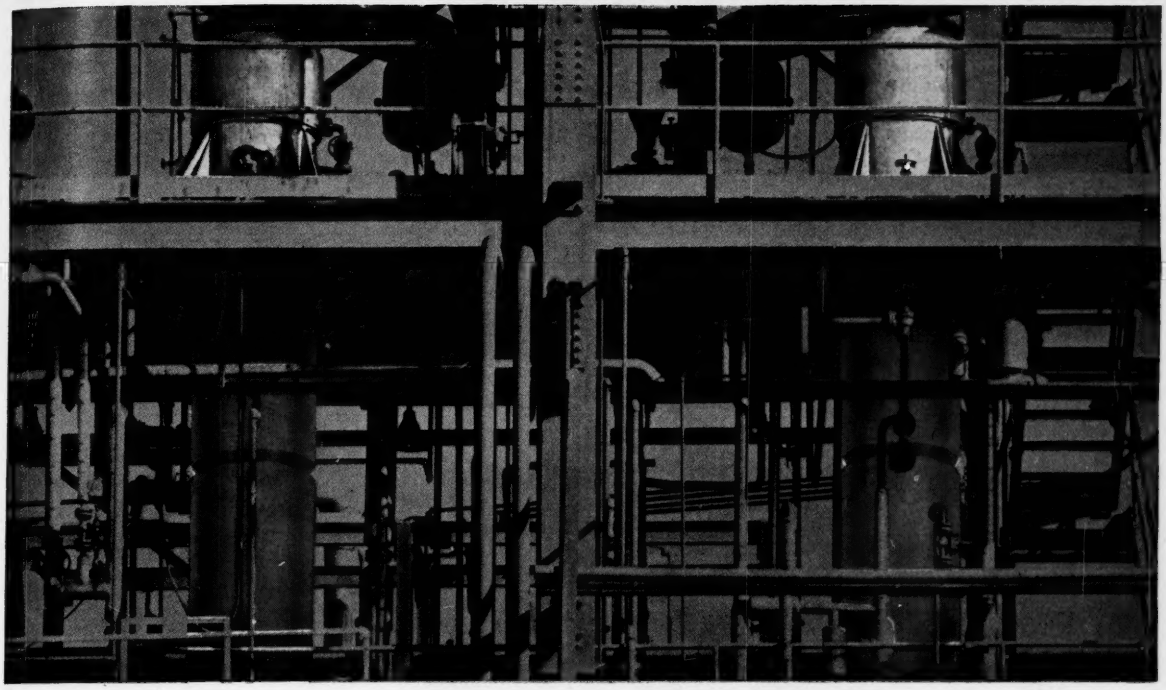
Equipment Cost Indexes

	Sept. 1956	Dec. 1956
Industry		
Avg. of all	211.3	218.3
Process Industries		
Cement mfg	201.6	208.6
Chemical	211.5	218.8
Clay products	195.8	202.6
Glass mfg	199.8	206.7
Paint mfg	203.5	210.5
Paper mfg	203.8	210.9
Petroleum ind	207.7	214.9
Rubber ind	210.3	217.6
Process ind. avg	209.0	216.2
Related Industries		
Elec. power equip	213.4	220.8
Mining, milling	212.8	220.2
Refrigerating	237.3	245.9
Steam power	199.2	206.1

Compiled quarterly by Marshall and Stevens, Inc. of Ill., Chicago, for 47 different industries. See *Chem. Eng.*, Nov. 1947, pp. 124–6 for method of obtaining index numbers; March 1957, pp. 266–7 for annual averages since 1913.







Turba-Film Processor produces epoxy compounds at Shell

The chemical and processing industries recognize that good engineering is just as important as good equipment. In recent years, Rodney Hunt has accumulated broad experience in specialized applications of the Turba-Film® Processor as well as in completely engineered package systems.

Shell Chemical Corporation produces petroleum-based resins at its plant near Houston, Texas. The process involves removal of the solvent carrier to give a dry epoxy compound. Rodney Hunt engineers proved the patented Turba-Film Processor ideal for this application. The Turba-Film permits a high degree of solvent removal with greater through-put than conventional equipment. Solvent and carrier pass through two Turba-Film units as a thin, falling film. Localized overheating is eliminated and product color is greatly improved.

Are you concerned with deaeration, deodorization, esterification, concentration, stripping, distillation, evaporation or other processing operations? Chances are good that Rodney Hunt can give you profitable answers to your problems.

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SERVING THE CHEMICAL AND ENGINEERING INDUSTRY WITH EQUIPMENT AND ENGINEERING

Sheet Insulation

Applies directly to vessels with cement.

Armaflex foamed-plastic insulation now is available in sheet form for use on large tanks of all shapes, irregular vessels and oversize piping.

As clean and flexible as rubber, Armaflex sheets can be applied directly to clean surfaces with cement, eliminating need for conventional mechanical supports. The material forms a permanent, almost perfect barrier to passage of air and moisture. Thus, no exterior vapor barrier is needed.

Armaflex is physically and chemically stable, resists deterioration year after year. Conductivity rating is 0.27 at 70 F. mean temperature. High-temperature limitation is 160 F.; there is no low-temperature limitation. — **Armstrong Cork Co., Lancaster, Pa.** 196A

Protective Coating

Resists attack by corrosive liquids and gases.

"Maintz" is a new Hypalon based coating for severe corrosion service. It is chemically inert and highly resistant to oxidation, ozone, weathering, acids including nitric and chromic, chlorine, refrigerants, grease and many other chemicals.

This coating is particularly suited for protection of both buildings and equipment as it forms a resilient surface which can withstand extremes of expansion and contraction without cracking. It may be applied by brush or spray to metals, wood, concrete, masonry, cloth and other elastomers. — **West Chester Chemical Co., Box 39, West Chester, Pa.** 196B

Plastic Lining Material

Ideal for lining reactors, pipe, hoppers and fume hoods.

Kel-F plastic laminate is a new material exhibiting extreme chemical resistance to acids, alkalis, oxidants and most solvents. It can be cemented to any surface of almost any contour, even the largest vessels where other materials and dispersions fail.

The non-toxic, non-contaminating plastic fused into glass cloth has a temperature range of −100 to +350 F. It presents a non-wetting and non-sticking surface with excellent abrasive resistance. Besides being suitable as a lining, the laminate can also be used to surface bench tops, floors, conveyor belts, etc.

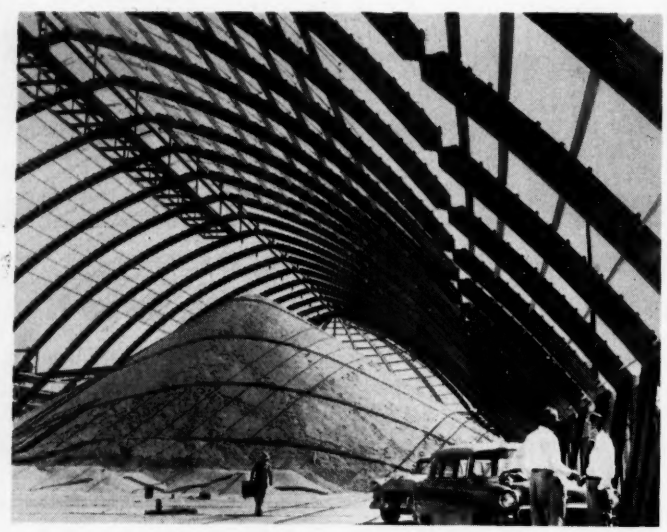
Other properties of Kel-F include vapor permeability, high tensile strength, non-flammability and zero moisture absorption.—**United States Gasket Co., Camden 1, N. J.** 196D

Shrunk Orlon Felts

Available for the first time on a commercial basis.

Felted Orlon materials are now ready for industrial wet and dry filtration applications and other uses where a complete felt structure is preferred.

The new chemically shrunk felts are currently manufactured in weights ranging from 8 oz. to 8 lbs./sq. yd. They are suitable for use in many applications which formerly used woven Orlon structures based on continuous filament yarn, which is no longer commercially available. — **American Felt Co., Glenville, Conn.** 196E



Timber-Framed Warehouse Built in Six Weeks

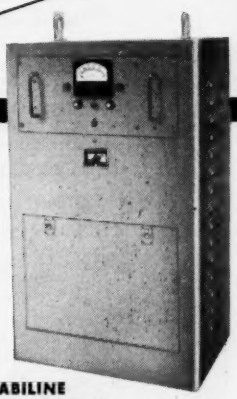
Unique in the annals of construction, this giant warehouse was erected around and over a pile of 80,000 tons of potash that Potash Co. of America had in open storage at Carlsbad, N. M. The 580x180-ft. structure is of an arched-bent design with timber buttresses anchored into a continuous, concrete pilaster wall which supports large, three-hinged, glulam Douglas fir wood arches. A waterproof glue was used because the timber buttresses extend outside of the pilaster wall where they are anchored in a welded steel assembly. Galbestos, a corrugated iron roofing with asbestos covering, forms the roof.—Timber Structures, Inc., Portland, Oregon. 196C

YOU GOT TROUBLES?

400 FLUORESCENT LAMPS . . . that did not need to fail!
1000 UNITS RETURNED AS FAULTY . . . that should never have passed inspection!
150 REJECTS . . . that never should have happened!
20 THYRATRONS . . . that should not have burned out!

a STABILINE® *Automatic* Voltage Regulator ends troubles like these!

Voltage variations can be a major contributor to maintenance and production costs. Many times Production Management has no idea at all that the losses are caused by voltage variations. Put this trouble-maker high on your check list. Use a STABILINE Automatic Voltage Regulator type EM to be sure that your electrical equipment operates at its most efficient rating — the nameplate rating at which it was designed to operate.



STABILINE type EM 6220Y holds output voltage constant . . . ends production and process troubles.

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Jet Stream Unloads and Dissolves Solids

Shipments of solids used for making solutions now can be unloaded and dissolved in a single, uniform, controlled operation that saves manpower, time and money.

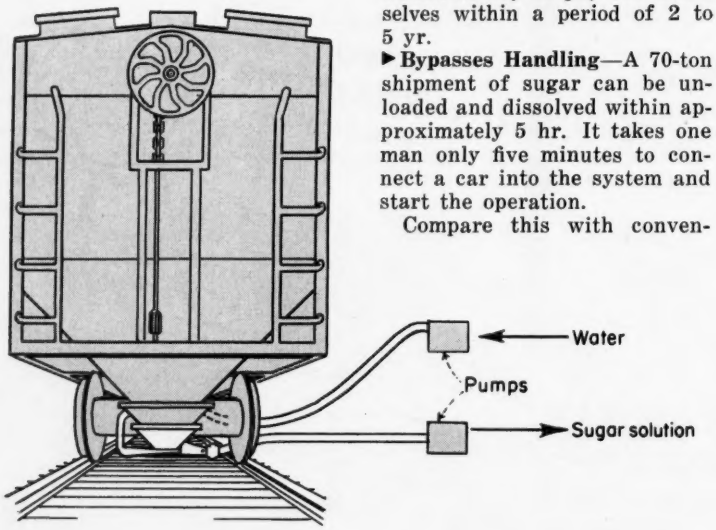
Out of the beet-sugar industry comes a new sugar-handling system that ultimately may find use with many other commodities shipped in bulk granular form.

Based on a device called the Liquilizer, the system unloads sugar and converts it to a heavy syrup in one continuous, self-regulating operation. And in a recent test, diammonium phosphate was unloaded from a bulk carrier and converted into liquid fertilizer.

Five installations now operating on sugar will save sufficient money to pay for themselves within a period of 2 to 5 yr.

▶**Bypasses Handling**—A 70-ton shipment of sugar can be unloaded and dissolved within approximately 5 hr. It takes one man only five minutes to connect a car into the system and start the operation.

Compare this with conventional handling where two men work 8 hr. to unload a car and stack the bags in storage. Before the sugar reaches point of use, it must be handled several more times, unbagged and converted to syrup.



LIQUILIZER bolts onto outlet of hopper car, mixes solution with solids.

▶**Closed Loop**—In a typical installation used for sugar, there are two storage tanks sufficiently large so that each can hold the liquid sugar resulting from a 70-ton dry bulk delivery. Recirculation lines run from these tanks through pumps to the unloading point.

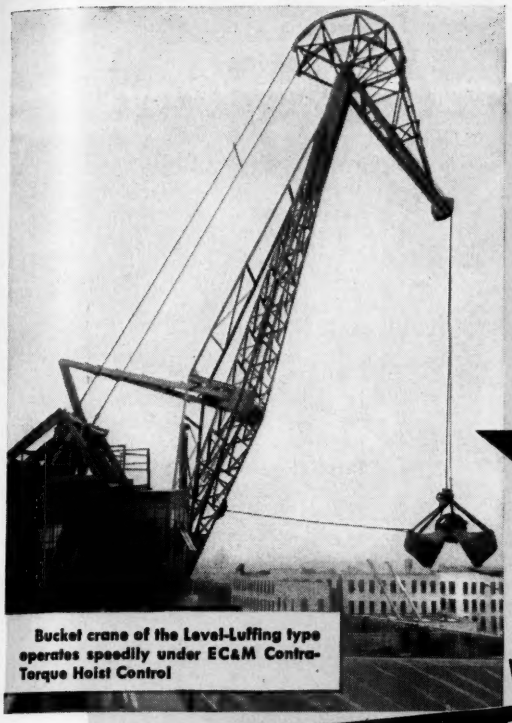
At the car, the recirculation line is coupled to the Liquilizer with snap-on fittings. The Liquilizer, in turn, is bolted to the discharge port of the car or truck.

To convert a carload of dry granulated solids to finished solution, the amount of water needed in the finished batch is metered into the tank. Then recirculation of water is started from tank to car and back. Finally, the discharge gate on the car is opened.

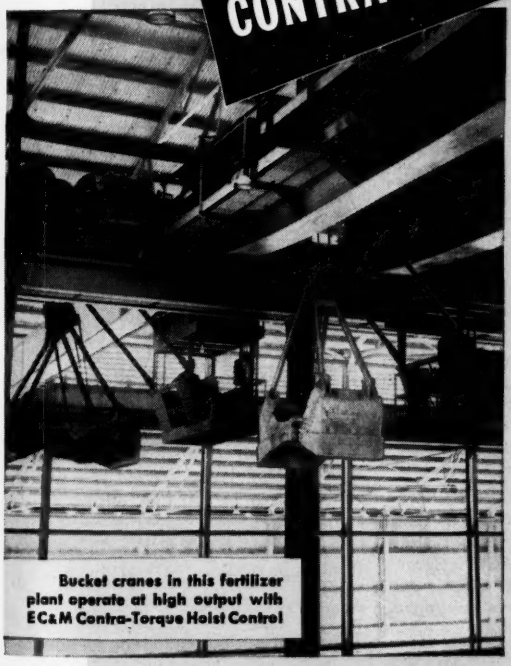
Water enters the Liquilizer through a flattened pipe that forms a wide, flat jet stream. Dry solids dropping through the discharge gate mix with this stream to form a slurry that flows back to the storage tank. Agitator in the tank keeps the slurry suspended until solution is completed.

▶**Runs to Completion**—Once the discharge gate is open there is no further need for regulation because the Liquilizer is self-regulating and will accept sugar only at a fixed rate. Therefore, no further attention is needed until the car is empty.

Liquid is circulated by positive-displacement, abrasion-resistant pumps—40 gpm. on the inlet to the Liquilizer and 120 gpm. on the outlet. Breathers in the Liquilizer assure uniform flow of solids into the flowing liquid.—**Amalgamated Sugar Co., Ogden, Utah.** 198A



Bucket crane of the Level-Luffing type operates speedily under EC&M Contra-Torque Hoist Control



Bucket cranes in this fertilizer plant operate at high output with EC&M Contra-Torque Hoist Control

HERE'S HOW EC&M FREQUENCY RELAY CONTROL improves A-C Bucket Crane performance

CONTRA-TORQUE®

FAST GETAWAY! Quickly responsive to the frequency of the induced-rotor voltage, **EC&M FREQUENCY RELAYS** match torque requirements to the load. They get the motor up to speed quickly for lowering the bucket and moving the trolley in or out. A lot of time saved between trips!

WIDE SPEED SELECTION! These relays permit pick-up of Contra-Torque lowering connections on any master switch speed point. No waiting until last down point is reached. Wider choice of speed gives greater flexibility in clean-up operations and speeds output!

SMOOTH STOPPING! When checking motor-lowering speed, weak torques are provided for light loads or the empty bucket; stronger torques for heavier loads. Trolley motor is stopped and reversed smoothly under frequency relay automatic operation!

SPEED-LIMITING! Safety on all speeds. These relays (one set for hoisting and lowering) automatically shift motor connections to safeguard lowering operation with far greater skill than human hands.

THE ELECTRIC CONTROLLER & MFG. CO.
A DIVISION OF THE SQUARE D COMPANY
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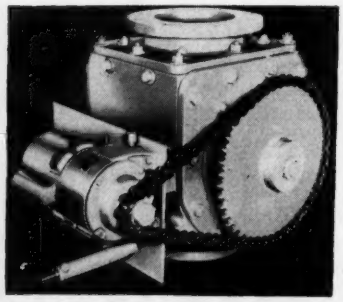


Rotary-Feeder

Handles dry, free-flowing granulated solids.

The A-S-H Type "B" rotary feeder was developed for such heavy duty applications as handling dry pulverized and granular materials. It features accurate feed control and positive shut-off.

The measured flow of material results from constant rotor speed and a rotor and shoe design that permits only a specific amount of material to fall into each pocket. Excess material cannot bypass the rotor.

The feeder is driven by a sprocket and chain from a gearmotor mounted on the side of the housing. As an automatic protective feature, the drive stops if jamming occurs.—**Allen-Sherman-Hoff Co., 259 East Lancaster Ave., Wynnewood, Pa. 200A**

Weigh Hopper

Provides "live bottom" discharge of solids.

Accurate weighing and discharge of fluffy or sticky materials is provided by a new bell-shaped weigh hopper with motor-driven screw discharge mechanism. The new hopper was designed for such difficult-to-handle material as long asbestos fibers, rubber crumbs and similar non-free-flowing materials.

Weigh hopper has three bell-shaped sides and one straight side to permit unrestricted flow of material. This design counteracts tendency of fluffy materials to arch in a hopper with four straight sides.

The weigh hopper is fully enclosed for dust-proof operation, with operating levers outside the weighing chamber. It is suspended from a set of beams and terminates in a dial head. Hopper can be fed from a bucket elevator, screw feeders or other conveyors, depending on requirements and is available in capacities of from 50 to 1,500 lbs. — **Richardson Scale Co., Van Houten Ave., Clifton, N. J. 200B**

Polyethylene Closures

Expanded line of closures serves more needs.

"CaPlugs" are ideal as dust and moisture seals and shipping protectors for delicate fittings, valves, hydraulic components and many machined parts. They can also be used for masking purposes during dipping, painting and vacuum plating.

Molded of tough, flexible polyethylene plastics, they are impervious to all common chemical reagents. Originally introduced as tapered, non-threaded closures to push on easily over pipe or tubing ends as caps, they are now available in 10 standardized designs (including threaded), stocked in over 300 sizes. — **Protective Closures Co., Inc., 2207 Elmwood Ave., Buffalo 23, N. Y. 200C**

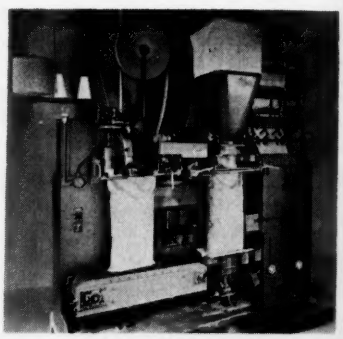
Screw Conveyor

For most free-flowing bulk materials.

The "Beeline" is a screw conveyor with new advantages for low-cost conveying of bulk dry chemicals. It has "automatic straightness" so that a 100-ft. run of the conveyor will be straight within a fraction of an inch without costly matching, fitting and customary installation adjustments.

Easier installation, greater operating efficiency and sharply reduced maintenance compared to other screw conveyors are further advantages.

Conveyor is offered in diameters from 4 through 16 in. and is constructed of components and accessories made to industry standards, allowing for interchangeability with equipment of other major manufacturers. — **Fort Worth Steel & Machinery Co., Fort Worth, Tex. 200D**



Automatic Bag Packer

Open mouth bags filled and closed automatically.

The VredOMatic packer extends fully automatic packaging to the filling of open mouth multiwall bags. The packer positions, opens, fills, closes and sews (with or without tape) open-mouth multiwall bags holding 25 to 125 lbs. of granular free-flowing materials.

It can also handle semi-free-flowing materials with auxiliary equipment. Used in combination with a pre-weighing scale, the system provides accurate weights at great speed.

Bag closures are tight and accurate since the system provides for proper control of the gussets and the bag top at all stages of filling and sewing. Production capacity is from 6 to 12 bags per minute. — **St. Regis Paper Co., 150 E. 42nd St., New York 17, N. Y. 200E**

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postcard inside the back cover

SCRUBOSPHERE* ...

... FOR *Cleaner Gas* AT *Less Cost!*

*PEERLESS SPHERICAL DUST and LIQUID SCRUBBER FOR GAS PIPELINES

(A) The majority of incoming liquid and solid particles are directed down into reservoir. 1

(B) Lighter solid particles carried by gas stream are separated on surfaces of contactor which are kept wet and clean by revolving thru liquid reservoir. 2

(C) Contactor is rotated by explosion-proof gear motor.

(D) Mist Extractor removes many remaining liquid particles from gas stream prior to outlet. 3

- The **dust removal ability** of the SCRUBOSPHERE **is superior** because it utilizes wetted surfaces for dust collection which are much more closely spaced than in conventional equipment.
- **Oil loss is minimized** because the oil used to wet the dust collecting surface is lifted mechanically instead of bubbling gas through the oil which results in foaming and loss due to creation of hard-to-separate fine particles.
- **Maximum performance and low cost** — The spherical design means high capacity and performance because it provides maximum dimensions for the contactor and mist extractor which normally are limiting factors in scrubber designs. The vessel cost is reduced because required vessel thickness is only one half that required for cylindrical vessel of same diameter.
- **Versatility** — separates solid and liquid particles with equal efficiency.
- **Low pressure drop** — ½ to ¾ psi at rated capacity depending on nozzle size.

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PEERLESS MANUFACTURING CO.

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Write for test data showing dust removal and oil loss of Peerless Scrubosphere as against conventional dust scrubber.

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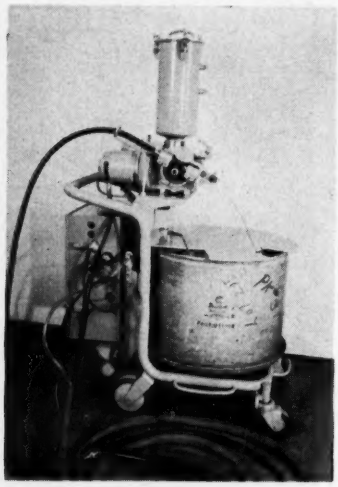

Arc Welding Machine

Revolutionary method of steel fabrication.

Unionarc welding is a new semi-automatic manual arc-welding process, using a continuously fed bare-wire electrode which is magnetically coated with flux at point of use. Welding arc, shielded in a CO_2 gas atmosphere, produces high quality welds and little distortion.

Combining the versatility of covered electrodes and high deposition rates of submerged arc welding, this efficient fast welding process affords excellent visibility of the weld zone, ease of operation, high current input, limited spatter, and continuous arc time.

Unionarc can be used in all positions at greater speeds and lower costs than covered electrodes. Less operator skill is needed. Welding speeds are 50 to 100% greater and total welding costs are 20 to 50% less than for covered electrode welding.—**Linde Air Products Co., 420 Lexington Ave., New York 17, N. Y.** 202A

Totally-Enclosed Motor

Direct mounting motor has advanced design.

A new motor with facilities for mounting the driven equipment directly to the motor has been developed. Designed to the new dimension standard of NEMA, the motor has more horsepower in less space.

Designated Type J, it is available in ratings of 1 to 30 hp. Cast-iron frame is heavily ribbed for great strength and rapid heat dissipation. Rotor is electronically balanced and solid cast. Roomy, split-dome conduit box makes it easy to connect the numbered leads.—**U. S. Electrical Motors Inc., Box 2058 Terminal Annex, Los Angeles 54, Calif.** 202B

Heat-Resistant Motor

Can withstand shaft temperatures up to 2,100 F.

Where the motor shaft may be subjected to temperatures as high as 2,100 F., a heat-resistant motor design features liquid cooling of shaft and electric windings.

The motor housing is positively sealed to make the motor suitable for operation under pressure or vacuum application. Liquid cooling of the motor enclosure permits operation under high ambient temperature conditions.

Motors are available in ratings from ½ to 30 hp. in standard induction motor speeds. Shaft sizes and extensions are furnished to accommodate specified load and speed conditions.—**Kaybee Engineering Co., 100 East Quincy St., Westmont, Ill.** 202C

Fan-Cooled Motors

New weatherized motors offer many advantages.

New line of totally-enclosed motors offers complete protection against moisture, dust and corrosive atmospheres. The motors have a die-cast aluminum rotor sprayed with a special rust inhibitor which covers entire assembly, including shaft.

Special insulation is used to provide extreme durability. The motors come with pre-lubricated sealed ball bearings and are available in ratings from ½ to 40 hp.—**Robbins & Myers, Inc., Springfield, Ohio.** 202D

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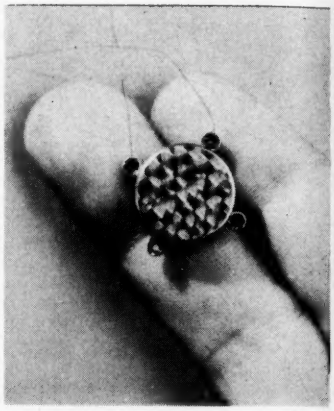


Atomic Battery

Delivers continuous electrical power for five years.

Tiny atomic-powered battery, which in shielded form is no bigger than a cough drop, can supply usable electric current for five years. The battery has a nominal output of 20 microwatts and is the first such device completely safe for extensive personal handling without special precautions.

The cell, which should be commercially available within three years, converts the decay energy from Promethium^{147} (half-life of 2½ yr.) into electricity through reaction with silicon photocells and use of phosphor materials. Greater power outputs can be obtained by connecting a number of cells in series. Battery operates satisfactorily at from −200 F. to +200 F.

Uses are foreseen in high-altitude missile and rocket work as well as in hearing aids and transistorized radios.—**Walter Kidde Nuclear Lab., Inc., 975 Stewart Ave., Garden City, N. Y.** 202E

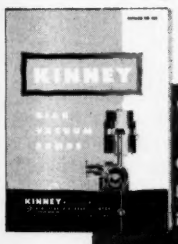
RIGHT! KINNEY SPANS THE WHOLE SUBJECT OF HIGH VACUUM

With the most extensive line of High Vacuum Pumps in the world, KINNEY encompasses the needs of laboratory, pilot plant and full scale production. The heart of your High Vacuum system is, obviously, the Pump . . . and it is certainly true that the performance of your system is definitely circumscribed by the capabilities of the Pump you select. The significance of the KINNEY name and KINNEY performance in High Vacuum work cannot be overemphasized.

What is true of KINNEY High Vacuum Pumps is also true of KINNEY High Vacuum Components and KINNEY-engineered Complete High Vacuum Systems. As the circle of High Vacuum technology widens, embracing more and more industries, the more important becomes the "know how" and experience of KINNEY engineering.

Name a High Vacuum System . . . KINNEY equipment offers plus factors beyond the specifications! Vacuum Furnaces, Ovens, Evaporators, Electronic Tube Evacuators and Aluminizers, High Vacuum Stills, Evacuators for Refrigeration and Air Conditioning, and ultra-High Vacuum for Nucleonics . . . KINNEY provides equipment of advanced design and interesting economy features.

What's your problem? If you're looking for answers in High Vacuum—*drop your slide rule and pick up the 'phone!* Call the KINNEY sales office nearest you or write today.



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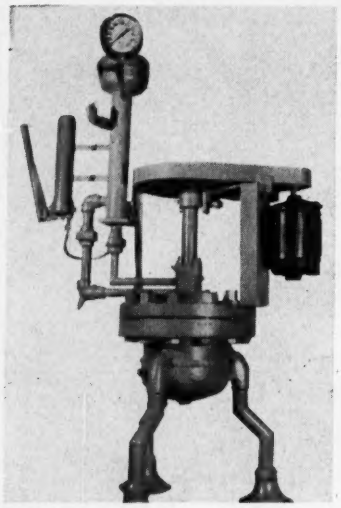


Autoclave

Glassed-steel construction for pressures to 750 psi.

Reactions up to 750 psi. can be handled by a specially designed autoclave constructed of glassed carbon steel. Unit offers the corrosion resistance of glass combined with the structural strength needed to withstand high pressures.

Agitation of the charge can be varied as needed through the variable-speed drive and the two-bladed, glassed-steel impeller. Provision has been made for a thermometer well and the non-metallic rotary seal is equipped with pneumatic lubrication. Capacities are 1, 2 and 3 gal.—**The Pfaudler Co., 1023 West Ave., Rochester, N. Y.** 204A

Rotary Dryer

Dries granular solids without losing fines.

Concentric fire-tube design of Carpco Dual-Flow dryers causes the hot gases to travel the full length of the dryer before contacting the feed. This prevents any direct impingement of flame on solids and provides indirect heating by radiation and direct heating by hot gases.

The outer shell of the dryer is lined with flights that pour the feed over the radiant inner shell while intimately contacting solids with hot gases passing through the annulus.

The two available models, RD1020 and RD1430, can evaporate 200 and 400 lb./hr. of water respectively. Throughput of bone-dry solids is 1 and 2 ton/hr. respectively when handling silica sand entering with 10% moisture. — **Carpco Mfg. Co., Jacksonville 6, Fla.** 204B

Small Mixer

Double-paddle type, has big-mixer features.

A small-size double-paddle mixer introduced recently is suitable for small batch mixing of paints, chemicals and inks. Unit has almost all features found in manufacturer's larger mixers.

Heavy construction is featured in this 8-gal. unit so that it can withstand the strains imposed by heavy mixes. Blades and can table are powered through a close-coupled drive arrangement by a 2-hp. motor. A hand tilting device to lift the paddles is balanced and pivoted for easy raising and lowering.—**The Cincinnati Hildebrand Co., 3410-H Beekman St., Cincinnati 23, Ohio.** 204C

Nitrogen Generator

Produces nitrogen cheaply at point of use.

Nitrogen with controlled hydrogen content and free of oxygen can be produced from ammonia at point of use with the new model GNLX Nitroneal generator.

Unit is cheaper to operate than older devices of this type and produces nitrogen at a cost much less than nitrogen in cylinders. Generator draws nitrogen from both air and ammonia, rather than from the ammonia alone.

Reaction is exothermic so that no external heat is needed. Unlike nickel catalyst used in conventional dissociators, the platinum catalyst in this generator lasts indefinitely.

Model GNLX can produce nitrogen with any hydrogen content between 0.25 and 25.0% without overheating the catalyst.—**Baker & Co., Inc., 207 Grant Ave., East Newark, N. J.** 204D

Liquid Separator

Offers high throughput in small unit at low cost.

Phasezon liquid separators, based on the same principles as the Podbielniak multistage extractor, utilize only the centrifugal separating features of the extractor without countercurrent mixing. The completely new device can separate any two immiscible liquids.

Mixed-liquid feed is introduced in a way such that settling distances are very small with respect to total liquid travel in the rotor. Centrifugal force up to 5,000 g., great coalescing area and very low liquid velocities in the rotor promote high quality separation and clarification.

Available units handle capacities from 200 cc./min. to 1,000 gpm. — **Podbielniak, Inc., 341 East Ohio St., Chicago 11, Ill.** 204E

Pilot-Dryer

Provides high degree of versatility for many needs.

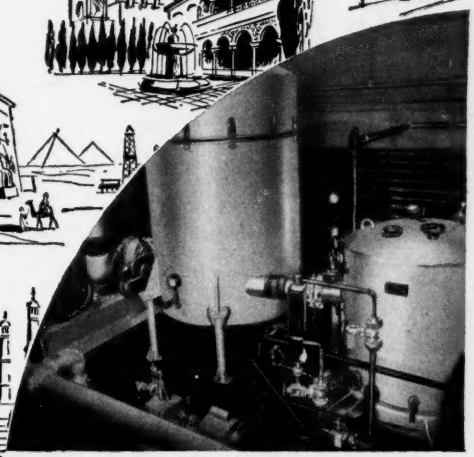
Only in custom-built equipment could you previously get the degree of versatility now offered in a new model pilot-plant and semi-works dryer .

Basic dryers in this series are suited ideally to studies of spray drying problems and to small production runs of ordinary products. Through modifications made in your own plant, you can adapt the basic units for use with viscous materials, for producing hollow spheres or thin-walled beads, or convert to a dispersion dryer.

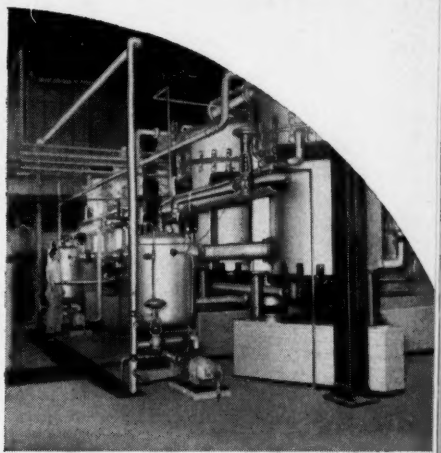
Normally, two fluid atomizers are furnished, but centrifugal atomizers can be supplied. The basic units can evaporate 15 to 75 lb./hr. and 30 to 150 lb./hr. Increases to 200 and 400 lb./hr. are possible with dispersion-type dryers. — **Proctor & Schwartz, Inc., 7th St. & Tabor Rd., Philadelphia 20, Pa.** 204F

CLEAVER-BROOKS
VAPOR COMPRESSION EVAPORATORS

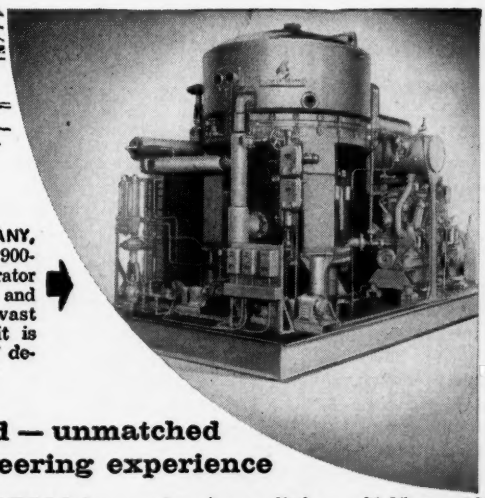
Field-proved by 12 years of service in 22 countries



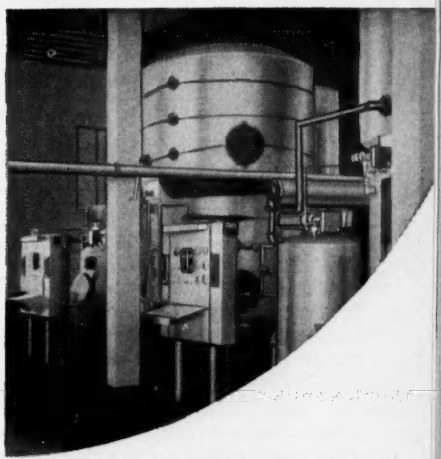
BROOKHAVEN NATIONAL LABORATORY, Long Island, N. Y., uses this 300-gph vapor compression plant to concentrate radioactive waste, thereby easing a hazardous storage problem.



ARROWHEAD AND PURITAS WATERS, INC., Los Angeles, Calif., produces chemically pure, USPH water for drinking and pharmaceuticals in this 100,000-gpd vapor-compression unit.



SAHARA PETROLEUM COMPANY, Alexandria, Egypt, employs a 900-gph vapor compression evaporator of this type to supply drilling and exploration camps with vast amounts of fresh water. Unit is typical of complete "packages" delivered to installation site.



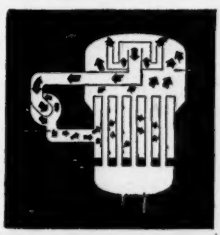
TOWN OF SALINAS, Ecuador, receives its entire residential fresh water supply from two 2100-gph vapor compression evaporators. This life-saving water supply (100,000 gpd) saved the town from being abandoned.

Leader in its field — unmatched application engineering experience

An oil camp in Egypt...an AEC lab in Long Island . . . a pharmaceutical plant in California...a coast town in Ecuador. *Just four of thousands* of Cleaver-Brooks vapor compression evaporators that are proving the economies of highly efficient operation.

Drawing from any raw water supply, sea water or even radioactive waste — these thoroughly field-tested units automatically produce distillate of highest purity, for as little as $1.25 per 1000 gallons of potable water.

Cleaver-Brooks is widely recognized as a leader in evaporation engineering — consistently solves pure water problems . . . with equipment designed for *most economical* operation. In addition to vapor compression evaporators, users also have a choice of multi-effect, flash and waste heat units in a wide range of capacities.



Vapor compression, the world's most efficient evaporation plant

Latent heat is constantly reclaimed by the compressor or "heat pump" and recycled through the evaporator. Up to 30 pounds of fresh water can be produced for every pound of diesel fuel used. Electric and steam-driven units consequently are economical to operate.

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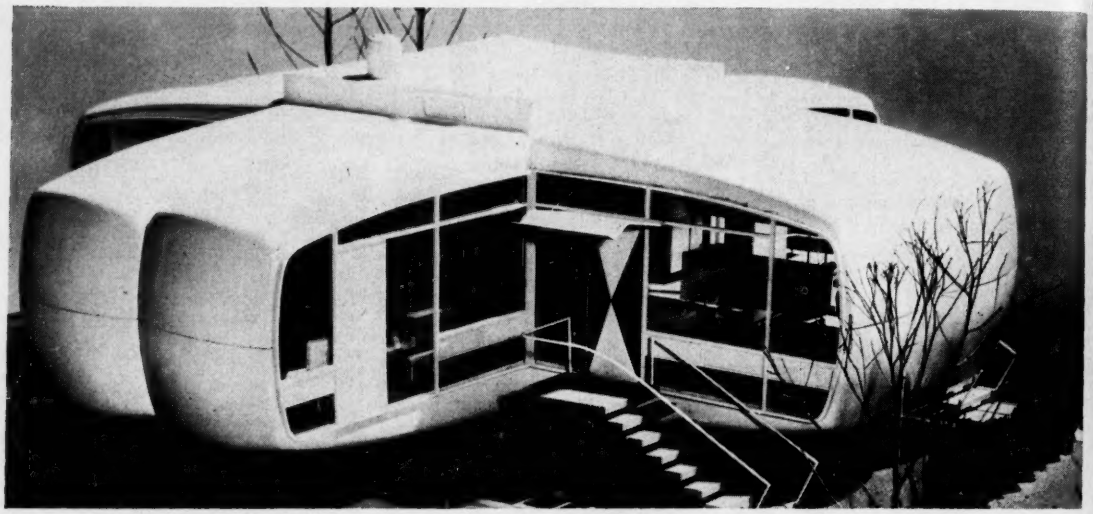


PLASTIC HOUSES—still a good ways off. But much closer than three years ago, close enough to make . . .

Plastics Makers Consolidate for Big Push

From special-purpose materials to building blocks —a hard transition. A surging plastics industry gets set to make a try.

Frances Arne, Assistant Editor

Plastics producers passed the 4-billion-lb./yr. mark in 1956, a 10% increase over 1955 on top of a 30% hike the previous year. In a couple of years plastics have shouldered their way into the ranks of the major materials, crowding such materials as copper and rubber and leading others like ceramics, aluminum, zinc and leather. One spokesman lists still another impressive comparison: Total volume (cu. ft.) of plastics produced is equivalent to that of aluminum, copper, lead and all other nonferrous metals combined.

Much more important, though, is the significance behind the statistics: Plastics are now produced in enough volume to be of real interest in a market like building—not merely as preeminent special-purpose materials but as basic materials.

▶ **Volume's Not Enough**—Yet to seriously compete with such basic commodities as steel, lumber, brick and glass for building jobs calls for more than tonnage production, and a pretty heterogeneous production at that. It calls for standardization and stability of price, of quality, of supply. It calls for exhaustive performance data.

Here's what's happening as the plastics industry seeks to meet these needs:

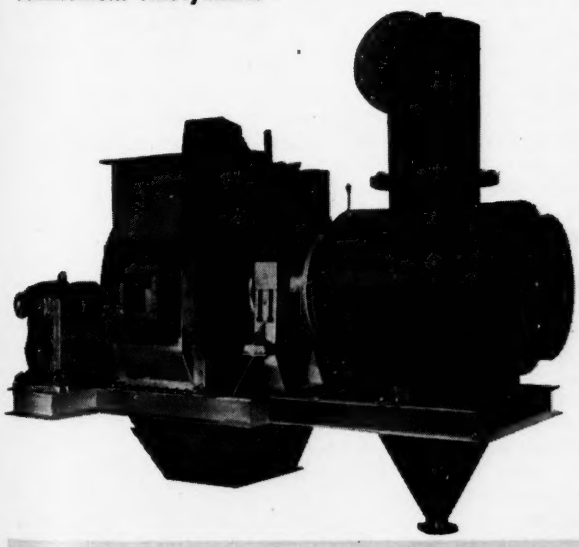
• Lower, more stable prices are in the cards as rising production capacity surpasses existing demands and plastics enter broadside, all-out competition against established commodities for king-sized markets like building and packaging. Prices dropped during the past year on vinyls, styrene, acrylics. And with so much new capacity coming on stream in such a relatively short time, the challenge of polyethylene oversupply will probably soon have to be countered with lower prices. Natural price direction for older materials, on the other hand, is up with the general economy. And their maintenance costs remain high while plastics' maintenance costs remain practically nil.

• Standardization is a word heard increasingly around the industry. Volume production increases the need for volume markets. Volume markets demand establishment of several basic resins as true commodities that can be ordered with the same confidence as alloy steel.

• Mergers and consolidations of existing companies continue at a rate which would indicate that, in the future, production of plastic materials will be centered in a rather small number of large companies. One example: Recent acquisition of Visking Corp. — largest polyethylene film producer—by Union Carbide's Bakelite Div.—

EIMCO DRYER HANDLES ABRASIVE CRYSTALLINE SLURRY

Decision of a large American producer of gas, fuel and chemical by-products to install an Eimco Top Feed Continuous Vacuum Dryer, was the result of their need for equipment to dewater and dry Ammonium Thiocyanate.



The extraction of this chemical from coal is unique to this company.

The processes used produce NH_4CNS in crystal form and the crystals are precipitated prior to drying. The extremely corrosive slurry is fed to the Eimco through a 20 × 20 mesh screen, .019 inches open.

Stainless steel materials of construction have resisted the highly abrasive physical characteristics in the feed to provide trouble-free, low maintenance service since 1941.

The 4′ × 2′ Eimco Dryer has 25 square feet of producing area. It processes 4,000 lbs. of concentrate per day (160 lbs. per square foot of filter area per day). Further economies are realized through the nominal BTU requirements necessary to dry a pound of NH_4CNS.

Eimco Top Feed Dryers have been particularly successful in plants dewatering slurries with fast settling solids of a granular or crystalline nature . . . and in processing heavy metallurgical feed where filtering rate justifies continuous operation.

Eimco's Research and Development Center at Palatine, Illinois, provides you with the most competent in manpower and facilities to help you choose the proper unit for your filtration problem . . . Let them go to work for you — today!

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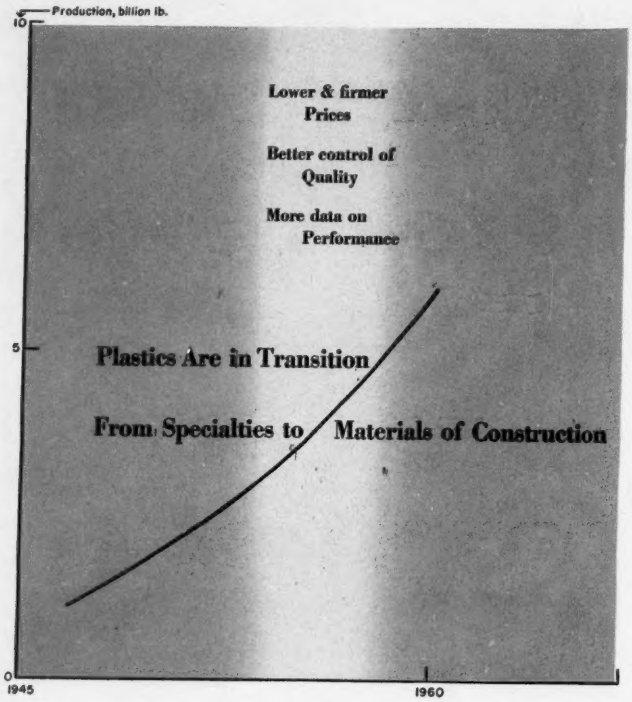


largest single plastics raw material producer.

What with all the leveling and adjustment going on it's not surprising that most plastics raw material producers string along with the Society of the Plastics Industry's January prediction of a conservative 5% production increase this year.

For steady, rather than phenomenal, is adjective favored to describe expected growth of most plastics categories for awhile. Such old standbys, for example, as urea and melamine resins are expected to comfortably expand from 312 million lb. last year to 340 million lb. in 1960.

Polyethylene, the onrushing newcomer, is the exception. Between late this year and the end of 1958, an increase in 1956's 650-million-lb. capacity promises to make polyethylene the first billion-lb./yr. plastic.

▶ **Coin's Other Side**—This tendency among raw materials producers to consolidate gains and protect their rear has not been lacking, only less publicized, in the past. It is, in fact, the reverse side of the very coin of the industry's success: product development. On the more sensational side, product development has meant a flood of new products; on the other side, it has meant a flood of application data and application tailoring for older products.

While newer types of plastics (nylon, silicones, fluorocarbons and polyurethanes) have received most of the publicity, new uses for the older ones (phenols, vinyls, alkyds etc.) have been responsible for the large volume production increase.

Just within the past year, cellulosics provided an excellent example of the kind of rejuvenating transfusion older plastics are continually getting from new markets. Discovery that cellulose acetate heels were ideal for ladies' shoes came late in 1955 to help save the cellulose acetate industry from perhaps the worst decline in the last five years. Because of the new market, acetate sales—down 15% in the first half of 1956—came back strongly enough to make 1956 one of the largest on record.

On the other hand, product development research is producing new materials so fast that the industry is often faced with the question: What do we produce before a new discovery comes along to make the new product obsolete? Fortunately the predicted market for plastics is large enough to remove much of the risk; conservative estimates place 1960 production at 5.5-6.0 billion lb.

▶ **Pinpointed Markets**—In the past, both application research and new product research have succeeded because of a technique for aiming at a specialized area of an over-all market in which plastics had certain advantages or could do a job no other material could do.

In piping, for example, industrial consumers are turning increasingly to plastics for meeting specialized needs. Their light weight and corrosion resistance mean drastic reductions in installation and maintenance costs. Sales volume at the consumer level in 1956 is estimated at about $60 million compared to $5 million in 1950. By 1960, output should be worth $90 to $100 million.

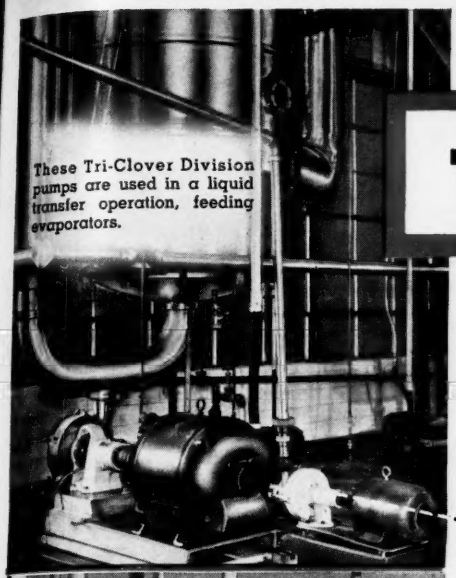
▶ **Broadside Markets**—But now plastics are big enough to logically aspire to a market like building—a market in which the home building segment alone will be worth $15 billion in the next 10 to 15 yr.

Complete acceptance of plastic pipe for household use alone would give the plastics industry a resin sale of 500 million lb./yr. (More realistic estimates, however, place actual potential at around 75 million lb./yr., or 15% of the standard steel pipe home market.)

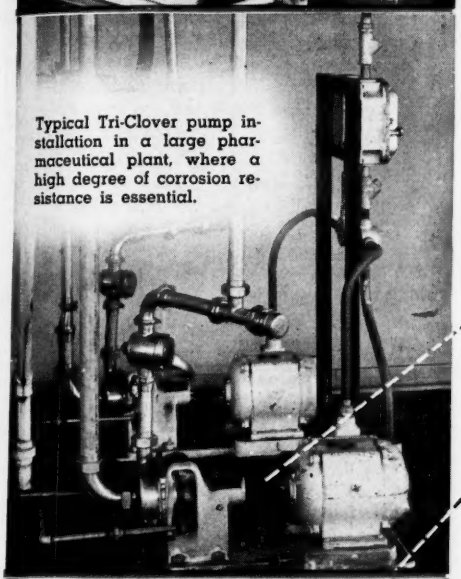
As a basic material of construction, any big share in markets of these dimensions would bring plastics production to a level far beyond today's predictions.

▶ **Standards Needed**—Lack of standardization is probably the main obstacle slowing broadside invasion of plastics in building and other structural applications. This despite the fact that virtually every principal type of plastic has made some vertical penetration.

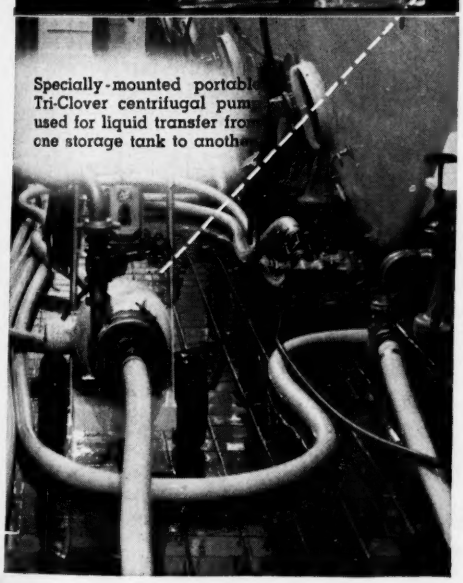
Floor covering has become a major outlet for vinyl chloride.



These Tri-Clover Division pumps are used in a liquid transfer operation, feeding evaporators.



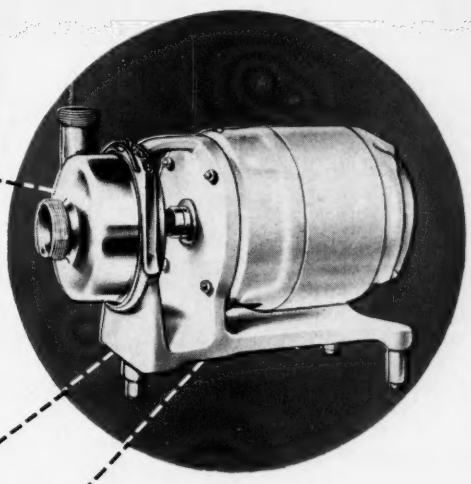
Typical Tri-Clover pump installation in a large pharmaceutical plant, where a high degree of corrosion resistance is essential.



Specially-mounted portable Tri-Clover centrifugal pump used for liquid transfer from one storage tank to another.

TRI-CLOVER

CENTRIFUGAL PUMPS



. . an efficient solution to corrosion-resistant pumping problems

Available in stainless steel, nickel alloy, bronze and cast iron, Tri-Clover Division pumps are designed for efficient liquid transmission with high resistance to corrosion. These modern pumps offer many exclusive features, including patented screw type impellers with quick-acting impeller clips, lightweight heads with a minimum of parts, casing construction permitting fast, easy assembly or disassembly—and a wide choice of seals for various applications.

Tri-Clover's exclusive developments are the result of many years of specialized engineering experience and thorough knowledge of liquid handling. Let our engineering staff work with you in solving your pumping problems.

See your nearest Tri-Clover distributor, or write:

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Tri-Clover Division
Kenosha Wisconsin

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High-pressure laminates have today expanded greatly into building applications in the form of melamine-faced, paper-backed, decorative phenolic sheets.

Flexible polyethylene (accounting for 80 to 90%) and rigid vinyl piping are being used in increasing quantities for water supply and for handling corrosive fluids, especially in the chemical industry. Foamed plastics are mostly used today in the form of prefoamed boards, especially foamed polystyrene. Foamed-in-place plastics, including polystyrene and the polyurethanes, are beginning to find use for hard-to-insulate irregular spots such as valves in hot lines.

However, one of the main reasons that Johns-Manville, for example, hasn't added one or more plastics to its line of building materials is fear of competition from lower-priced substandard materials. Builders are reluctant to use a material which may not last the lifetime of the building, and building code officials are reluctant to approve a material which may be a fire hazard. Not that plastics necessarily have a short life or are fire hazards, but there is a definite lack of available data on the subject.

▶**Standards Coming**—Steps are already being taken to counter the situation. For example, standards on flexible standard-wall polyethylene pipe and rigid polyvinyl chloride sheets have been issued recently by the Dept. of Commerce. At least a dozen proposed standards on various products are now in the hands of the Dept. of Commerce for analysis by the National Bureau of Standards before final issuance.

Another dozen proposed standards are currently being considered by different SPI committees on such products as flexible vinyl and urethane foams, polyvinyl chloride dip tubes, vinyl garden hose and reinforced plastics.

▶**Plastic House Promotion** — Management of raw materials producers is solidly behind more and broader applications work. Witness Monsanto, currently making a broadside attack on the home building industry with its all-plastics "House of Tomorrow" (photo, p. 206). Built at Disneyland, Calif., it is a continuing experiment on the use of plastics in construction.

Reinforced plastics provide the load-carrying structure as well as enclosure. Advantage is taken of plastics moldability to provide large curved shells capable of withstanding superimposed loads and of providing the necessary stiffness.

In addition to representing much-needed, intensive applications work and data collection, the all-plastics house represents the industry's traditional aggressiveness in the direction of new products. Says Monsanto's program director, "If we run into a structural application that looks good, but we don't have the material at hand, the chances are we can develop one to do the trick—that's plastics."

▶**Poly Leads the Pack**—Most striking of all on the new products front is polyethylene. In a six-month period during 1956, two producers introduced nine new polyethylene resins. And just over the horizon is a whole new batch that will come out when low pressure processes start producing temperature-resistant rigid polyethylenes.

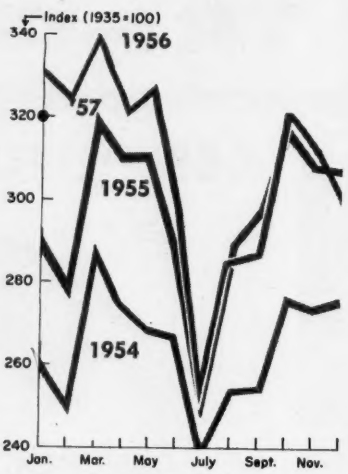
With the exception of polyethylene, there were no pronounced changes in production of basic plastic raw materials during 1956. Individual estimates for these several raw materials are: polyethylene, 541 million lb., up 30%; vinyls, 730 million lb., up 10%; styrenes, 636 million lb., up 4%; phenolics and other tar resins, 503 million lb., about the same as 1955; ureas and melamines, 312 million lb., about the same as 1955; cellulosics, 140 million lb., down about 10%.

▶**Price-Cut Pressure** — Impact of polyethylene, and to some extent the small quantities of low-pressure grade, has had repercussions among other segments of the plastics industry. Vinyls, for example, are exhibiting a slower rate of growth.

Additionally, a number of small vinyl producers have entered the field with resin plants sized at about 10 million lb., usually associated in the same corporate entity with captive outlets in the form of film and coated fabric. Price cutting has resulted; PVC resins are believed to sell for 25¢/lb. or under.

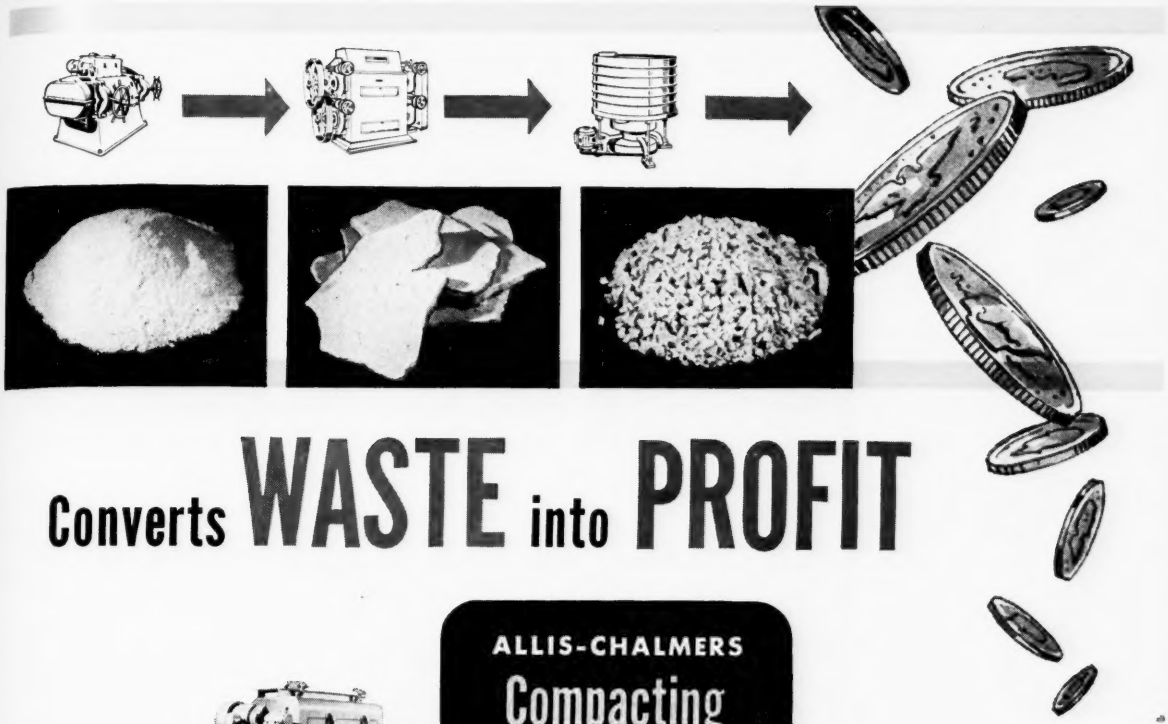
Polystyrene growth has likewise slowed over the past two years. There were gains in high-impact uses and losses to polyethylene in the housewares market. Styrene monomer price was broken by rubber users who threatened to build their own styrene plants unless the price became more realistic. As a result, rubber grade monomer will drop to 12¢ (from 16¢) in July 1957 and polymer grade prices may follow suit.

Chemical Consumption



Consumption by Industries

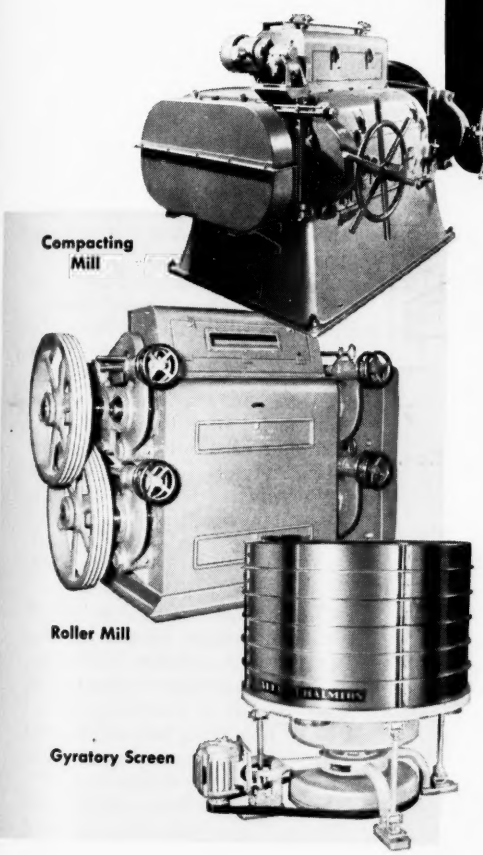
	Dec. (Final)	Jan. (Est.)
Coal products	12.4	12.1
Explosives	9.7	10.1
Fertilizer	69.4	73.6
Glass	23.5	25.8
Iron & steel	19.9	20.2
Leather	4.1	4.0
Paint & varnish	23.4	30.2
Petroleum refining	32.8	32.1
Plastics	23.2	24.1
Pulp & Paper	34.1	38.5
Rayon	27.7	31.0
Rubber	6.6	7.8
Textiles	9.5	10.3
Total	296	320



Converts WASTE into PROFIT

ALLIS-CHALMERS Compacting Process

it's mechanical
it's economical



You start with a pile of practically worthless material and wind up with a profit! Magic? Well, hardly – unless you want to call the mechanical efficiency of the Allis-Chalmers Process System magic.

How It Works

In a recent installation the conversion starts with an unusable, unacceptable minus 30 mesh chemical salt . . . fines created in the original process. An Allis-Chalmers compacting mill densifies these fines into flakes or slabs. Flakes are granulated in an Allis-Chalmers roller mill. Final separation is made in an Allis-Chalmers stainless steel gyratory screen. Result – 70 to 80% recovery of salable product. What's more – the resulting granules equal or surpass the natural product in every respect.

The entire system is mechanical; therefore, it's more economical than controlled crystal growth.

For More Information

Get the complete story from your A-C representative or write Allis-Chalmers, Industrial Equipment Division, Milwaukee 1, Wisconsin. Ask for Bulletin 25C6177J.

ALLIS-CHALMERS

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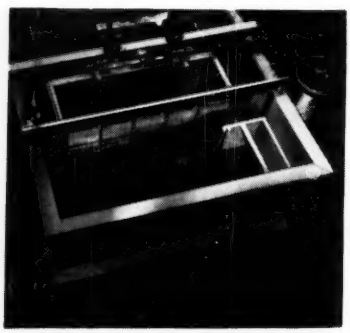
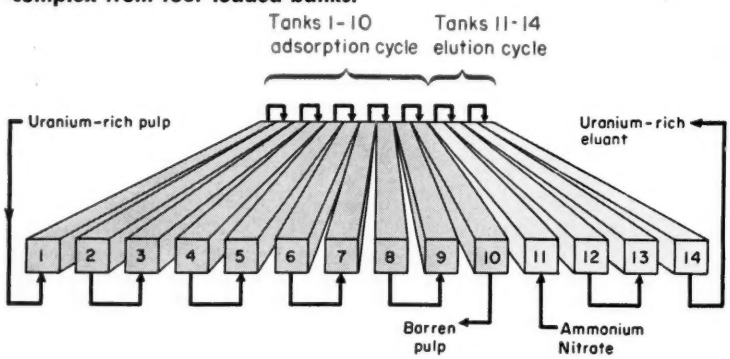
XUM

Resin-in-Pulp Ion Exchange Wins U_3O_8

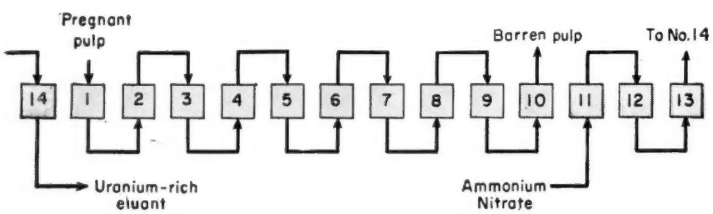


Resin-filled baskets dip through slime-thick pulp produced by H_2SO_4 leach. Fluidization keeps slime from sealing ion exchange bed, allows resin to adsorb uranium complex without usual, costly filtration steps.

Ten RIP banks adsorb uranium from leached ore as eluant strips ion complex from four loaded banks.



No. 1 bank swings to elution when loaded, No. 2 takes lead position. Eluted bank joins adsorption end.



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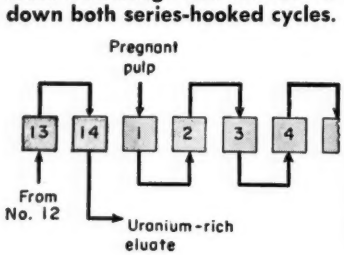

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Unfold Flowsheet

XUM

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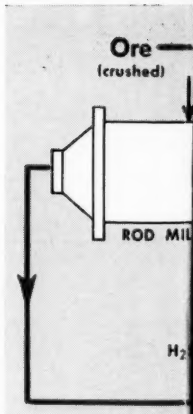
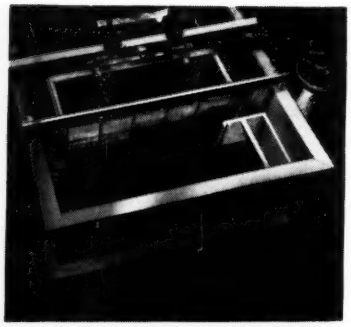


1 **ROD MILL: in a neutral**

Resin-in-Pulp Ion Exchange Wins U_3O_8



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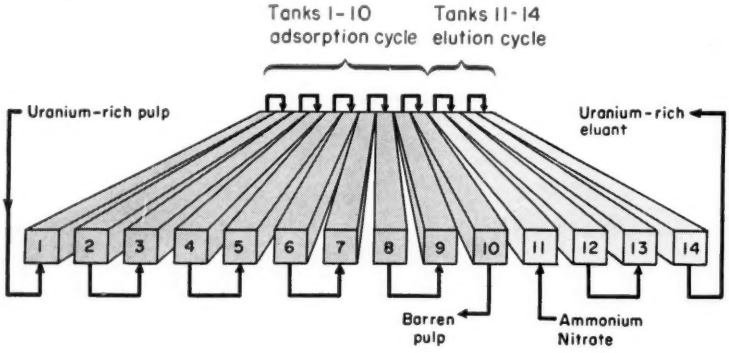

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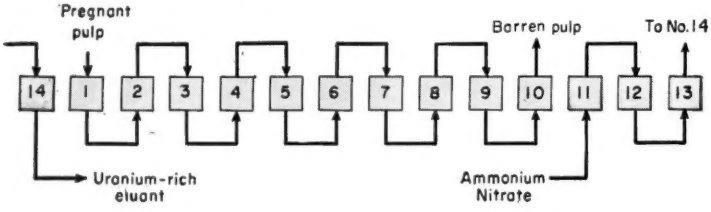

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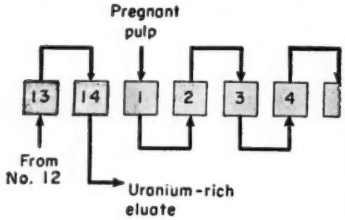

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XUM

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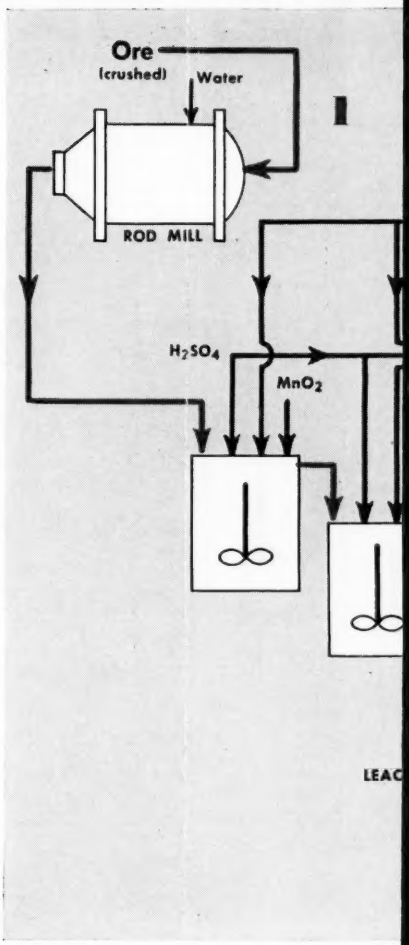

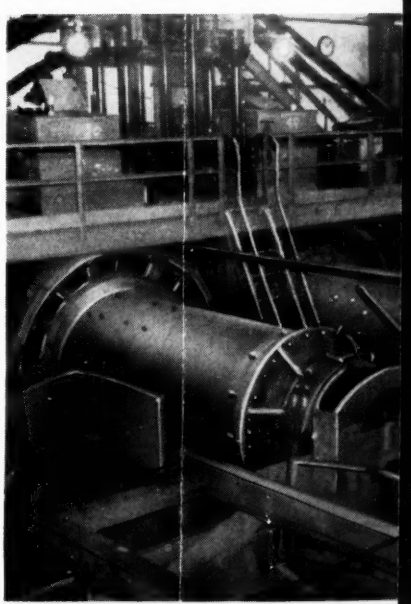

1 **ROD MILL: Blended sandstone-lim in a neutral water solution to −10**

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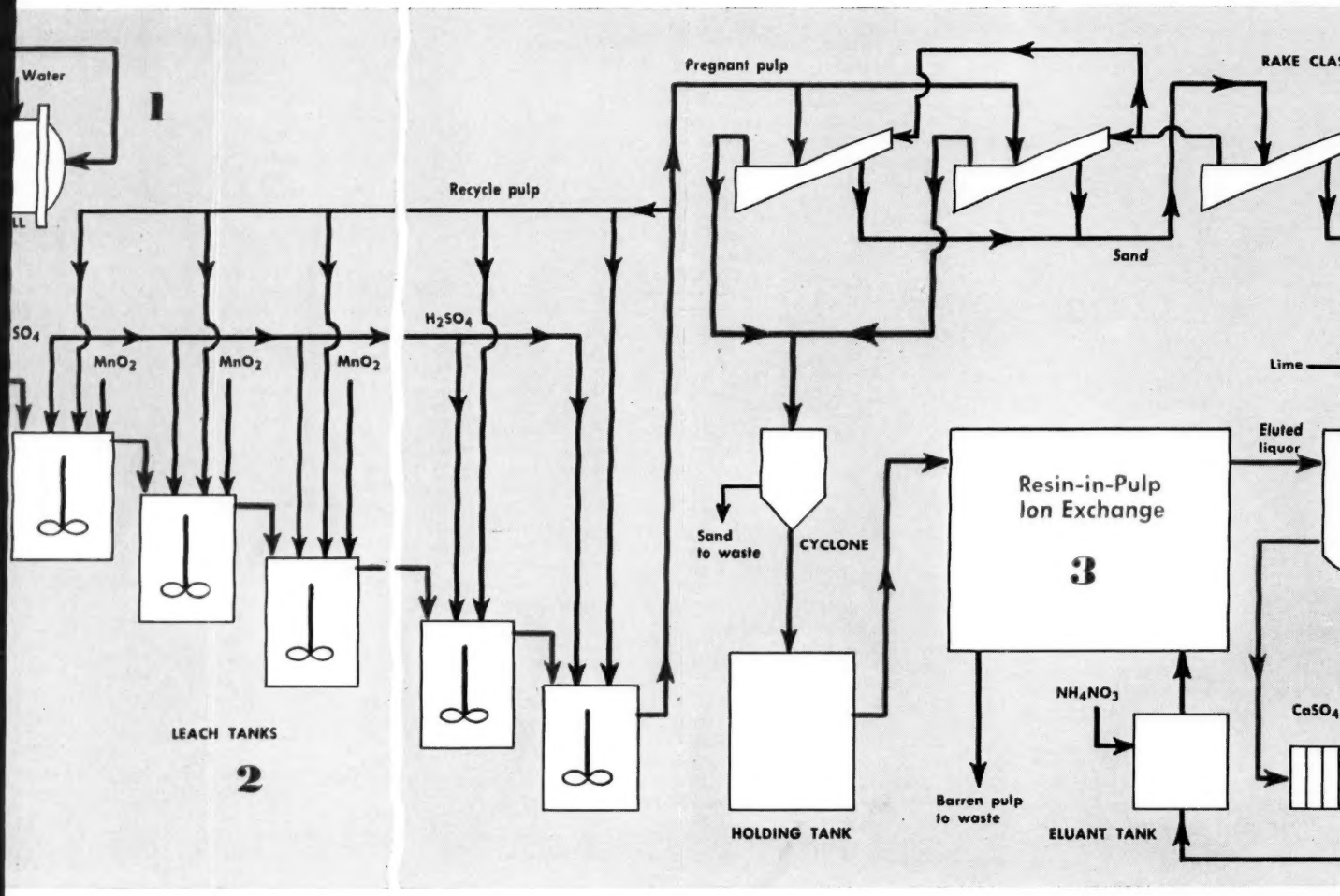
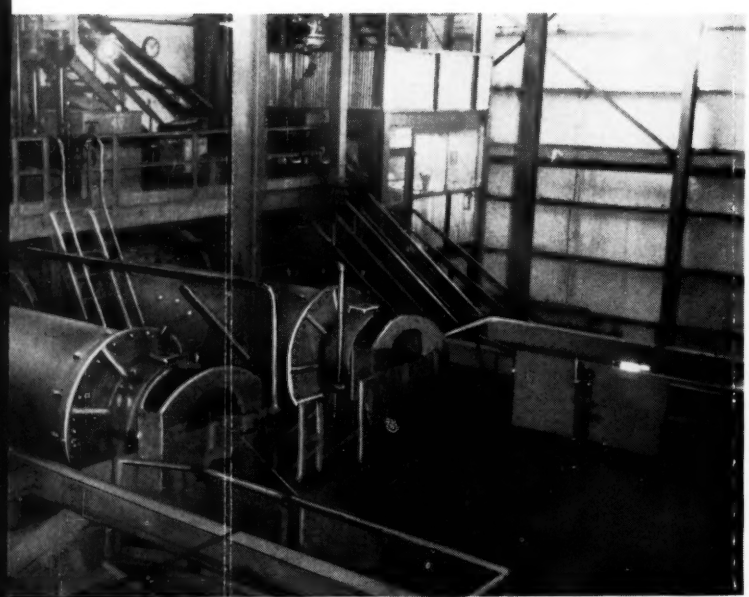
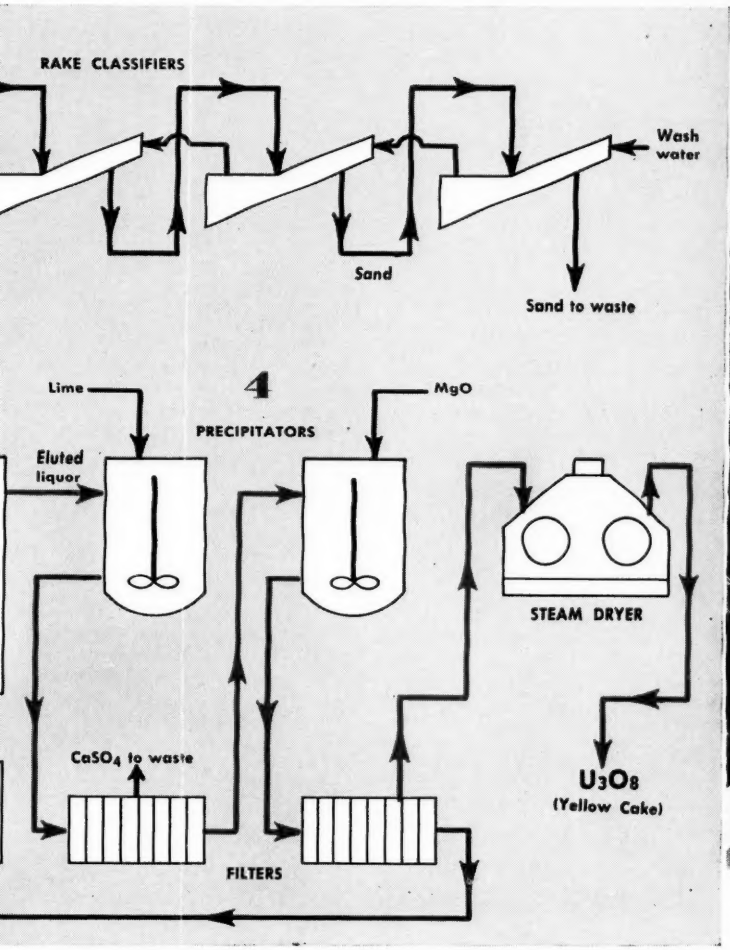


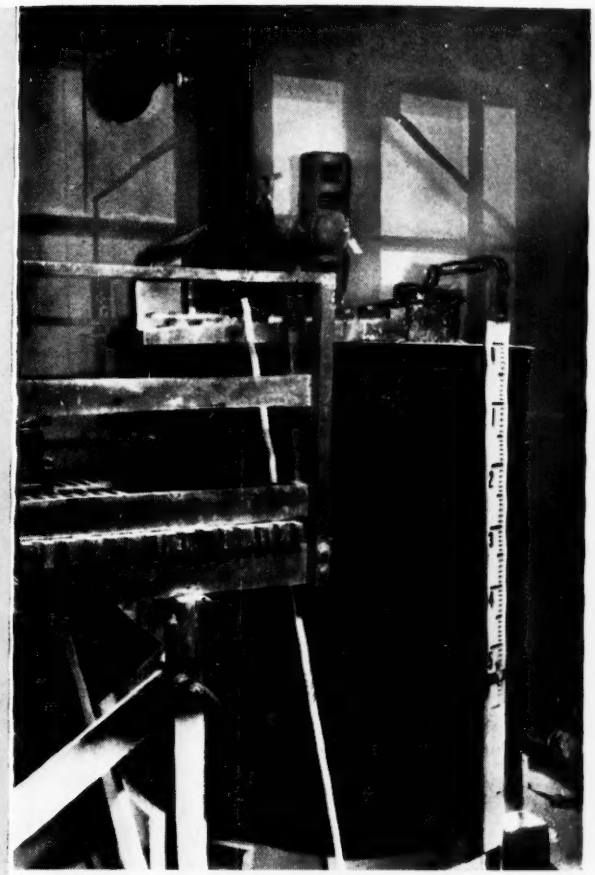


Blended sandstone-limestone ore, first reduced in a jaw crusher, is ground water solution to —10 mesh to ease handling of acid-circuit feed at outset.

2 LEACH TANKS: Sulfuric acid, MnO_2 feed to first eight of 1 series-hooked, neoprene-lined steel agitation tanks to produce u

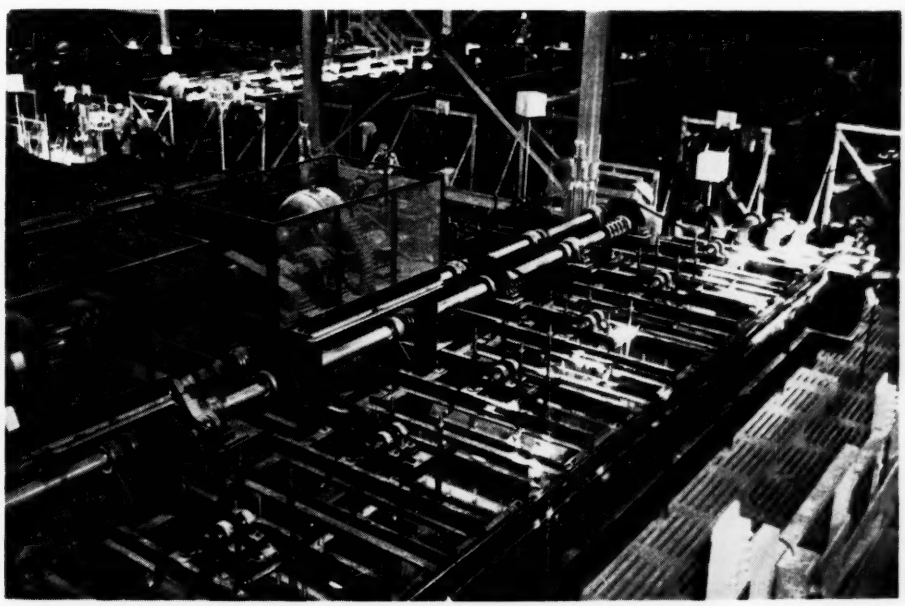
XUM





4 PRECIPITATOR: Lime precipitates $CaSO_4$, iron in 18-ft.-dia. by 20-ft.-high steel tank at pH 3.5.

t eight of 14, 13-ft.-dia. by 14-ft.-high to produce uranium-bearing pulp.



3 RIP BANKS: Pulp feeds to 14. series-hooked, 50 x 6 x 6-ft., neoprene-lined steel tanks, each fitted with 10 stainless steel, 4 x 4 x 4-ft. baskets holding 15 cu. ft. of resin.

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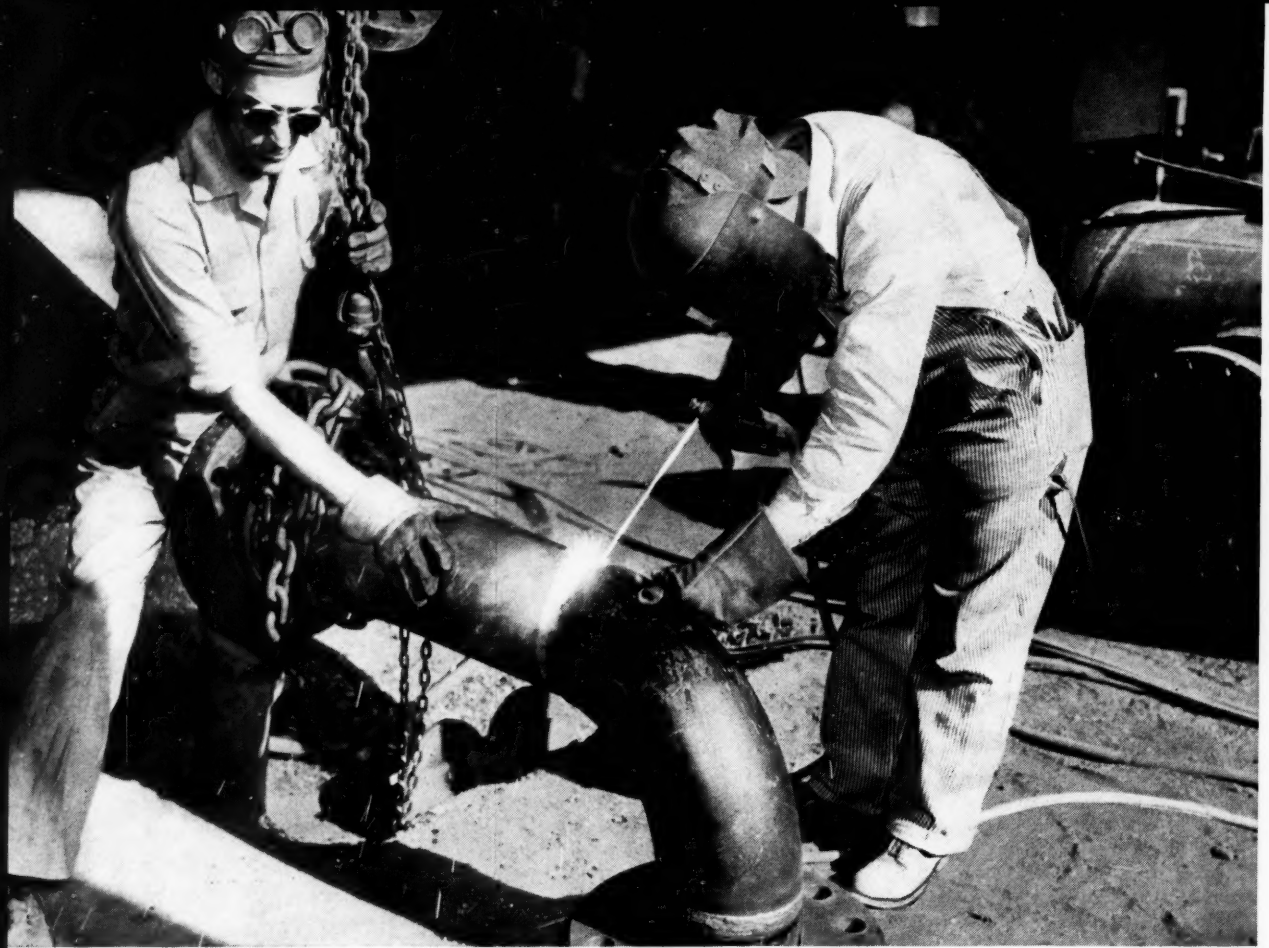

When Specs Demand Job Matched Piping and Fittings One Call Will Do it All—B&W

The layout has been made. Erection schedules are in the planning stage. What you do now in contacting a source of supply for your alloy steel pipe fittings and flanges, can very well be one of your most important moves.

If you call on B&W, you can be assured of benefits that simplify scheduling problems. With one call to B&W—on one order—you can obtain matched pipe, fittings and flanges to meet your specific requirements. What's more—the delivery of the alloy steel pipe, the seamless welding fittings, and the forged steel flanges that make up the integrated system you desire—can be coordinated. This is just one more reason why B&W has earned the reputation and acceptance as "the natural source" for alloy pipe and fittings.

Call on Mr. Tubes at your nearby B&W Tubular Products Division District Sales Office—let him coordinate your alloy steel pipe, seamless welding fittings and forged steel flange problems. He can help you. The Babcock & Wilcox Company, Tubular Products Division, Beaver Falls, Pa.

TA-7009-PP3

Seamless and welded tubular products, seamless welding fittings and forged steel flanges—in carbon, alloy and stainless steel.

World's Largest Sea Water Salt Plant Proves Crane Valve Quality

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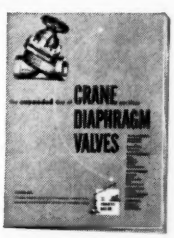

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cuts the cost of powdered materials

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Economically

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Practice

Resin-in-pulp technique captures U_3O_8 . . . TURN BACK TO P. **228**

AEC-Anaconda ion exchange method seeks out uranium complex from acid leach minus costly filtration steps.

Biochemicals **237**

It's one thing to make them—quite another to get at them. Last April we discussed the former; here now is the latter.

Spotlight on maintenance **252**

With automation in high gear, process industry plants bulge with costly equipment. Upkeep is profit safeguard.

Dust off your cost estimate data **257**

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What about flow in stacked towers **259**

In April, we talked about stacked packings generally. Now, we'll discuss their quantitative flow relations.

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When your own reference books and files fail to help, these calculation methods will probably do the trick.

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This month: file references on pump selection and costs; ion exchange and exclusion; electric motors and drives.

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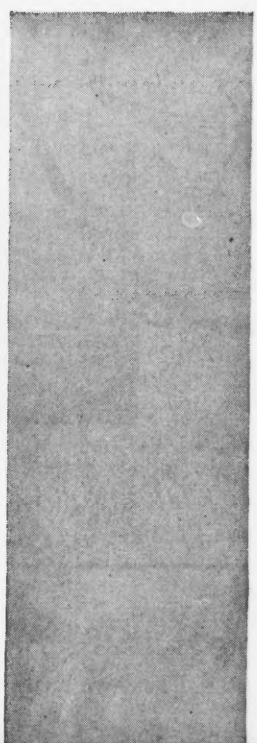

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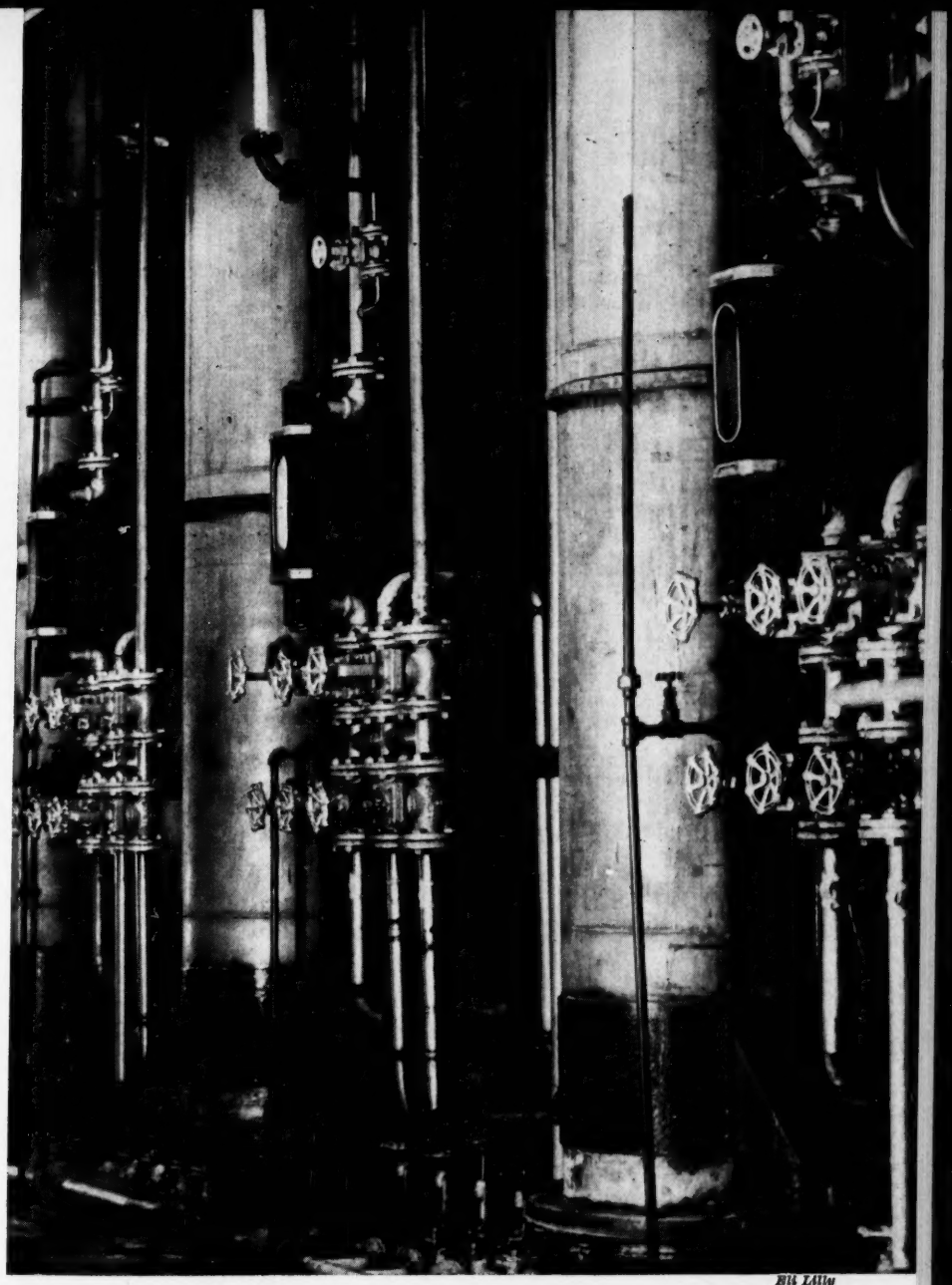


Eli Lilly

Biochemicals Processing

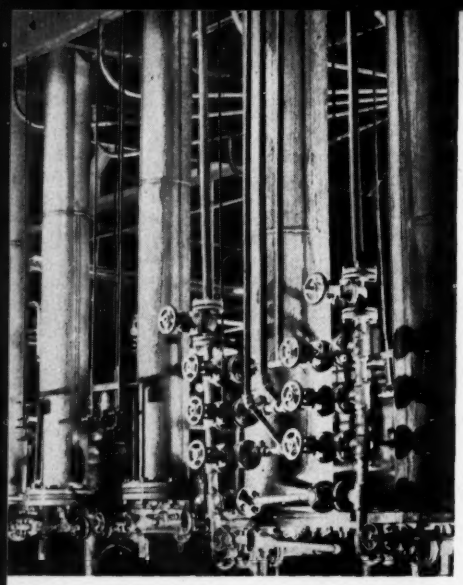
ELMER GADEN, JR., Columbia University*

REDUCED to simplest terms, biochemicals processing is "smart engineering dedicated to control of quality."

To follow this theme, chemical engineers must resolve a seeming contradiction: From the crudest, most complex, most sensitive mixtures can come chemicals of the highest quality and specificity—at a profit.

Their work is a cross between looking for a needle in a haystack

* Meet your author on page 326.



ION EXCHANGE: Prime choice for separation and/or purification of biochemicals.

and picking mercury off the floor.

Their ways are processing labyrinths marked by novel, and necessary, twists.

That chemical engineers do all this, and do it well, with the familiar separation tools and principles of their profession—such as extraction, adsorption, crystallization—justifies this report. It picks up where your author ended his survey of fermentation processes last year (*Chem. Eng.*, April 1956, pp. 159-174).

And it comes as a logical sequel to that other report because the processor with a crude biochemical source is still a long, long way from a finished product.

This report shows how he gets from source—be it a fermentation broth, synthesis mixture or extract from some natural material—to a finished, salable commodity.

From the Crudest

Biochemical mixtures exhibit characteristics which make them, when compared with more conventional process materials, a singular group. The most important of these characteristics are:

- Over-all complexity, not only because of the large number of components within a given mixture but also the close structural relationships, isomeric and otherwise, between components of the mixtures.
- Individual complexity, with predominance of large, complex, unstable molecular structures.
- Extremely low concentrations, ranging in commercial practice from the order of several grams to at low as a few milligrams per liter.

Each of these characteristics can be demonstrated in a wide variety of materials frequently encountered in chemical processes. Only in mixtures of natural substances, however, do they regularly occur simultaneously and in extreme degree.

An excellent example of complexity in both individual structure as well as over-all composition is found in petroleum processing. Furthermore, minute quantities of certain critical impurities—heavy metals like nickel and vanadium, which act as potent catalyst poisons—are also encountered. Of course one could argue that petroleum is, after all, a biochemical mixture, too. The real difference is in average molecular stability.

The formative processes which give rise to petroleum in the earth have degraded originally deposited plant and animal matter to a range of molecular species which, though immensely complicated, is quite stable. Refining processes may then employ levels of treatment—distillation, solvent extraction, acid washing—which would be out of the question for the original materials from which the petroleum crude is derived.

Although the variety of constituents found in biochemical materials is legion, a few typical examples may be cited for illustration.

Protein Chemicals Gain Favor

Proteins are characterized by high molecular weights, over a million in many cases, and extreme sensitivity to heat, H^+, OH^-, metallic ions, and many other chemical and physical agents. Proteins are common, and often the main, components of biochemical mixtures. Their very special properties are freqently the limiting factors in determining the separation processes which can be applied.

Besides their fundamental role in animal nutrition, proteins are commercially valuable in a number of ways. Many crude protein products like adhesives are real old-timers, with little or no refinement involved. More recently, however, attention has turned to a number of special protein preparations including:

- Purified amino acids for nutritional supplementation and therapy.
- Protein hormones, blood plasma fractions, vaccines and serum preparations for preventive medicine and therapy.
- Enzymes for industrial and pharmaceutical applications.
- Bulk proteins for conversion to textile fibers, coating and viscosity control agents, etc.

Mixtures . . . Biochemicals of the Highest Quality

Proteins: Big, Touchy, Active

Chemically, proteins are condensation copolymers of amino acids. Natural proteins contain varying amounts of up to twenty different amino acid monomers, and commonly attain molecular weights of 15,000 to 1,000,000. Certain complex proteins exhibit much higher molecular weights, up to 10 million.

Not only may the proportions of these constituents vary, but also their relative positions in the polymer molecule, providing the basis for an almost infinite range of protein properties.

The condensation linkage characteristic of protein molecules is the "peptide-bond" formed between NH_2 and COOH groups of different amino acids. Chain branching occurs because some amino acids have multiple amino and carboxyl groups. On hydrolysis, proteins yield mixtures of their constituent amino acids. Fig. 1 summarizes the essential features of protein chemistry.

Usually the "physical" rather than the "chemical" properties of proteins dictate the separation and purification procedures which may be used.

Several aspects of protein behavior are particularly important when separation is considered. These are electrical (ionic) character, solubility, and denaturation and coagulation.

Proteins Act As Electrolytes

Since amino acids and their protein polymers contain ionizable NH_2 and COOH groups, they behave as electrolytes. This is usually represented by the general equilibrium:

$$\underset{\text{(cationic)}}{R\cdot CH(NH_3^+)\cdot COOH} \overset{H^+}{\rightleftarrows} \underset{\text{(isoelectric)}}{R\cdot CH(NH_3^+)\cdot COO^-} \overset{OH^-}{\rightleftarrows} \underset{\text{(anionic)}}{R\cdot CH(NH_2)\cdot COO^-} + H_2O$$

The intermediate dipole with a net charge of zero is called the isoelectric form (zwitterion); the hydrogen ion concentration at which it occurs is then the isoelectric point.

Proteins exhibit this same behavior by virtue of their free, ionizable groups. They may act as gross cations or anions, depending on the pH of the surrounding solution, and migrate in an electric field accordingly. Isoelectric points range between 4 and 7 for most proteins with some notable exceptions.

Proteins do not enter into true solution; rather they form colloidal sols of varying stability. As the molecular weight of the polymer chain decreases, the solution state is more closely approached and the liquid becomes more and more stable. In the polypeptide range (intermediate hydrolysis) true solution becomes the rule.

Protein solubility is therefore markedly affected by the nature of the solvent and by the presence of other dissolved electrolytes. At the isoelectric point the colloidal protein sol is stabilized only by solvent adsorption since it no longer possesses any net electrical charge. Hence the isoelectric form exhibits minimum "solubility".

This stabilizing influence of the solvent can be lessened by adding other electrolytes to the solution, effectively reducing the solvent concentration. Electrolyte precipitation is most effective at the isoelectric point where solubility is already at a minimum. Ammonium sulfate has long been the favorite protein precipitant although others are used occasionally.

Protein Denaturation: Help and Hindrance

The term denaturation refers collectively to a number of changes in the properties of proteins. It is very difficult to define it more clearly and the alternative description of "coagulation" is probably as good. By far the most obvious feature of protein denaturation is a notable decrease in solubility.

On the whole denaturation is undesirable and must be avoided in protein processing. On the other hand, where proteins are present as impurities, denaturation may be deliberately practiced in order to eliminate them from the process liquor. An example is the pretreatment of fermentation broths with acid and heat to coagulate the cellular matter present.

Common denaturants are heat, acids, alkalis, organic solvents, certain cations, ultraviolet light, and even high pressures. Some highly complex proteins are so sensitive that even mild mechanical shock—from stirring or shaking—will induce denaturation.

It is clear, then, that this tendency on the part of proteins will always be a prime consideration in selecting separating techniques.

Antibiotics, Vitamins: Complex, Dilute

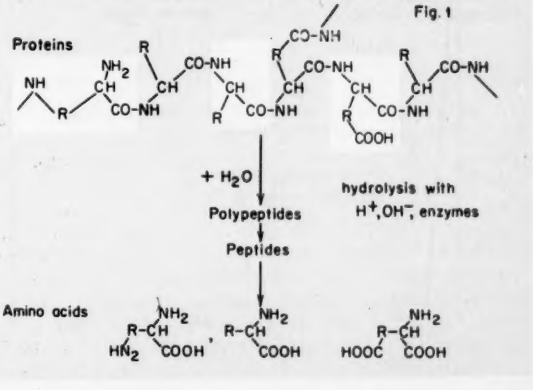
Antibiotics are complex organic materials of moderate molecular weight. As such they are often unstable, at least in part, and subject to loss of desired therapeutic qualities.

Vitamins and hormones are physiologically active substances, exhibiting a wide variety of structures and molecular weights, which must be separated from primary natural sources, recovered from fermentation broths, or isolated from synthesis reaction mixtures.

Antibiotics and certain biosynthesized vitamins like riboflavin and B_{12} are materials of high unit value appearing in raw fermentation broths in extremely low concentrations. For example, at the end of the fer-

Protein Hydrolysis Splits Out Amino Acids

Fig. 1



Biochemical Materials—Trouble in Triplicate

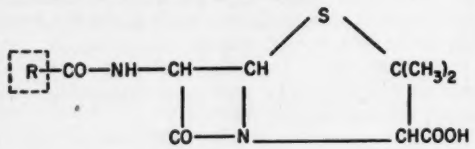
Fig. 2

SCARCITY: Biochemicals rank with the "rarest."

Product	Source	Concentration
Titanium	Quebec slag	400,000 ppm.
Helium	Natural gas	40,000
Copper	Typical ore	10,000
*Antibiotic	Fermentation broth	1,500
Magnesium	Seawater	1,300
Gadolinium	Bastnasite ore	1,000
Uranium 235	Uranium 238	700
*Reserpine	Plant root	500
*Steroid	Fermentation broth	75
Bromine	Seawater	65
Neon	Air	15
*Vitamin B_{12}	Fermentation broth	1

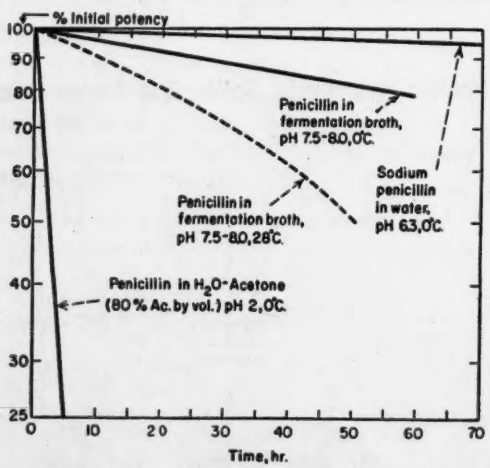
COMPLEXITY: Many isomers; one wanted.

Example: In penicillin biosynthesis . . .



Wanted	R
Benzylpenicillin	$C_6H_5CH_2$
Other isomers	
n-Heptylpenicillin	$CH_3(CH_2)_6CH_2$
p-Hydroxybenzylpenicillin	$HOC_6H_4CH_2$
n-Amylpenicillin	$CH_3(CH_2)_3CH_2$
2-Pentenylpenicillin	$CH_3CH_2CH=CHCH_2$

INSTABILITY: In a matter of hours, little may be left.



mentation cycle penicillin titers now run around 1.5-2 gm./liter, riboflavin a little higher and streptomycin perhaps as high as 4 gm./liter. These are typical.

Vitamin B_{12}, on the other hand, appears in concentrations of only 1-2 mg./liter (1-2 ppm.).

Recovery problems are due mainly to the low concentrations in which these chemicals are found and to the need to free a highly pure primary product from trace contaminants of structurally similar but biologically inactive or harmful entities.

Penicillin, a Case in Point

At least five different, but closely related, penicillins are found in fermentation broths (Fig. 2). Of these, only one, benzylpenicillin (or penicillin G), is therapeutically used.

As the structures show, there exists no overt chemical difference between these substances which can be used for separation. Instead we must rely on slight differences in physical properties, mainly solubility, to isolate benzylpenicillin.

This problem is further complicated by the relative instability of benzylpenicillin under various process conditions, also shown graphically in Fig. 2. It is necessary, unfortunately, to apply some of these conditions, like low pH, if maximum solubility differences needed for recovery are to be realized.

Penicillin is an extreme example, but certainly not the only one. Two forms of the antibiotic streptomycin and three of neomycin are known. The peptide antibiotics (bacitracin, polymixin, etc.) are found with a wide variety of closely associated proteinaceous substances.

Pyrogens Plague Processors

In the manufacture of chemotherapeutic agents, like the antibiotics and hormones, from natural sources, one particularly troublesome class of impurities is encountered. These impurities are, in the main, complex carbohydrate substances which cause a rise in body temperature on injection—hence the name "pyrogen." Materials for injection must be virtually free of these agents. To insure their elimination, great care is exercised in treating even the process water used in the final stages of purification.

Another feature of natural materials should be noted here. The term "mixture" is being applied in the main to homogeneous, single-phase liquid solutions. Found in many biochemical mixtures, however, are solutions well into the colloidal range, as well as "micro-suspensions" of considerable stability but not permanence.

SEPARATION

Chemical engineering—conventional in principle, original in execution—wins biochemicals from involved sources.

Since the separation of mixtures is an old and honored occupation of chemical engineers, a wide variety of techniques are available. Generally the problem is one of selecting the most effective and economical of these for a particular case.

In handling biochemical mixtures, however, none of the more conventional operations may be completely

These Separation Processes Used in Biochemical Technology

Evaporation • Distillation • Sublimation

RECOVERY FROM NATURAL SOURCES

Vitamin A—Molecular distillation of fish oils to produce vitamin concentrates.

RECOVERY OF FERMENTATION PRODUCTS

Streptomycin—Concentration of acid eluate from ion-exchange columns by vacuum evaporation.

Vitamin B-12—Vacuum concentration of final aqueous solution; B-12 crystallized from concentrate.

Riboflavin—Spray-drying of whole broth for animal feed supplement.

Penicillin—Freeze drying of bulk penicillin crystals.

Adsorption, Non-Selective

RECOVERY OF FERMENTATION PRODUCTS

Vitamin B-12—Adsorption from clarified fermentation broth on activated carbon.

PURIFICATION

Aureomycin—Removal of organic impurities from butanol extract with activated carbon.

Adsorption, Selective

RECOVERY OF FERMENTATION PRODUCTS

Streptomycin—Adsorption from whole fermentation broth on weak cation-exchange resin; elution from resin with HCl or H_3PO_4.

PURIFICATION

Amino Acids—Group separation of amino acids from hydrolysis of proteins into acidic, neutral and basic groups.

Proteins—Removal of inorganic ions from protein fractions obtained by salt precipitations; mixed resin bed.

Blood—Exchange of Na^+ for Ca^{++} to prevent coagulation in processing human blood.

Chemical Precipitation

RECOVERY FROM NATURAL SOURCES

Gamma-Globulin—Fractionation of human plasma by precipitation with alcohol.

RECOVERY OF FERMENTATION PRODUCTS

Terramycin—From clarified fermentation broth (1-5 gm./liter); precipitated as quaternary ammonium salt.

Riboflavin—From clarified fermentation broth (1-3 gm./liter); precipitated by reduction with sodium dithionite.

PURIFICATION

Streptomycin—Precipitation as $CaCl_2$ "double-salt" from concentrated eluate from ion-exchange.

Solvent Extraction

RECOVERY FROM NATURAL SOURCES

Fats & Oils—Extraction of oil seeds, animal glands, etc. with hydrocarbon solvents (hexane), ketones, ethers.

Plant Extracts—Medicinal extracts, flavors, etc., from plant leaves, roots, etc., by percolation with water and alcohol.

RECOVERY OF FERMENTATION PRODUCTS

Penicillin—Extraction from whole fermentation broth (1-3 gm./liter) with amyl acetate.

Bacitracin—Extraction from clarified broth (0.5-1 gm./liter) with butanol.

PURIFICATION

Penicillin—Extraction and re-extraction from acetate to buffer to chloroform to buffer; fractionates penicillin isomers.

Vitamin B-12—Extraction of crude B-12 concentrate (50 mg./liter) with benzyl alcohol.

Dialysis

PURIFICATION

Enzymes—Removal of metal ions and low-molecular-weight organic impurities from enzyme preparations.

Beet Sugar—Separation of sugar from colloidal matter in leach liquor.

Electrophoresis

Proteins—Fractionation of crude protein mixtures.

Thermal Diffusion

Proteins—Enrichment; protein fractions concentrate preferentially in thermal column.

Foam Fractionation

Proteins—Separation of proteins from impurities; enrichment of protein mixtures.

Enzymes—Separation of peroxidase from catalase; pepsin from rennin.

Fats—Fatty acids from bile acids in bile preparations; sterols.

Crystallization

RECOVERY OF FERMENTATION PRODUCTS

Gluconic Acid—Direct crystallization of crude sodium gluconate from clarified fermentation broths (25-30% soln.).

PURIFICATION

Vitamin B-12—Crystallization of B-12 from aqueous concentrate.

Penicillin—Procaine penicillin crystals from procaine hydrochloride solution of crude Na or K penicillin.

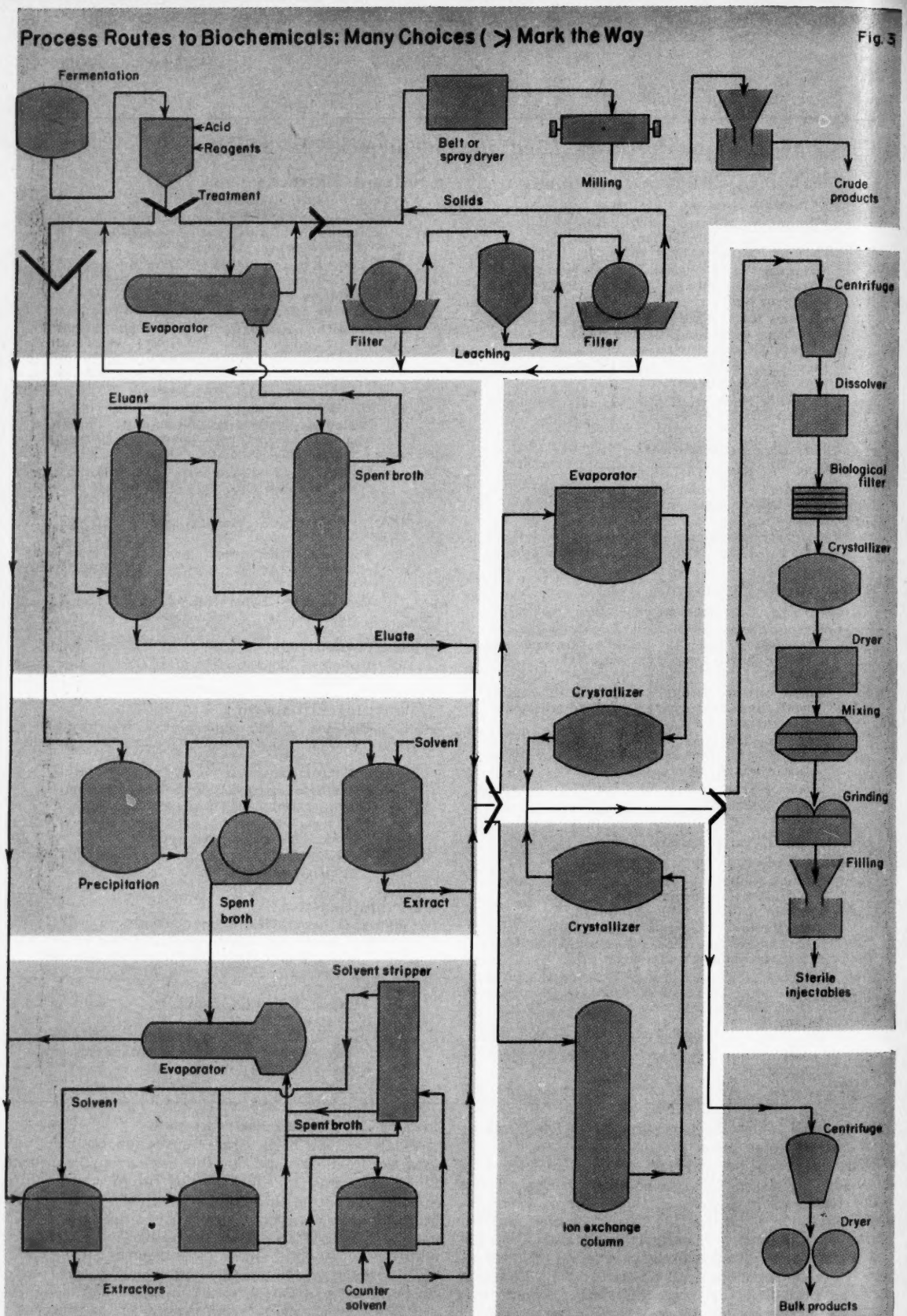
adequate and it may be necessary to modify them or even develop some novel procedure.

Practically any property of a liquid mixture may be made the basis of a separation process. Those properties most frequently employed for solutions include solubility, volatility, surface adsorption and ion exchange, diffusivity, molecular size and electrical charge. By restricting examination to liquid systems which are homogeneous, or effectively so, separation methods dependent on gross physical property differences—screening, filtration, settling, etc.—may be disregarded.

Let's Classify Biochemical Separations

Whatever the basis used, separation methods fall into two main groups. In the first group, a second phase is formed in which concentration relationships are different from those of the original solution. This second phase may arise either by altering the heat content alone (evaporation, crystallization) or by the addition of another immiscible component (extraction, adsorption, etc.). In the latter case we are faced with at least a ternary system; in the former, a binary.

Table I breaks these groups down further into unit operations and into specific process applications.


Process Routes to Biochemicals: Many Choices (≫) Mark the Way
Fig. 3
Fermentation
Acid
Reagents
Treatment
Belt or spray dryer
Milling
Crude products
Solids
Evaporator
Filter
Leaching
Filter
Eluant
Spent broth
Eluate
Evaporator
Crystallizer
Solvent
Precipitation
Spent broth
Extract
Crystallizer
Solvent stripper
Evaporator
Solvent
Spent broth
Extractors
Counter solvent
Ion exchange column
Centrifuge
Dissolver
Biological filter
Crystallizer
Dryer
Mixing
Grinding
Filling
Sterile injectables
Centrifuge
Dryer
Bulk products

While a variety of separation techniques exist, only a few are readily applicable to biochemical mixtures. For the factors of individual and over-all complexity, coupled with the extremely low concentrations of products, impose severe limitations.

Let's examine briefly some typical examples of the many diverse separation and recovery operations.

These examples are taken from (1) the refinement of protein and amino acid mixtures and (2) the recovery and purification of antibiotics and related fermentation products. These two process areas offer a good basis for case study since practically every separation technique of commercial interest has been employed to some degree in them.

Methods which have proven most useful for commercial fractionation of proteins are: electrolyte precipitation (usually $(NH_4)_2SO_4$); selective extraction and precipitation with solvents; electrophoresis. Unfortunately, ion exchange is not readily applicable to proteins despite their ionic character. The molecules are too large for even the most porous resins.

The processing of fermentation products involves:

- Pretreatment—removal by chemical treatment and filtration of suspended cells, unused raw materials, etc., which can interfere with subsequent treating operations.
- Primary recovery and volume reduction—object here is to win the product from the raw broth as completely as possible and reduce drastically the fluid volume being handled.

Economic recovery of dilute fermentation products requires rapid reduction in the large volumes of process liquor handled. Techniques most generally used, and shown in Fig. 3, are: chemical precipitation with selective agents; ion exchange; solvent extraction; carbon or clay adsorption.

- Purification—separation of the desired product from residual raw materials, byproducts and impurities.
- Finishing—a "catch-all" for all those operations which are used to put the product into a marketable form. In pharmaceutical production this may include the preparation of formulations, tabletting, etc.

There is often no clear distinction between these steps in any given process. For example, ion exchange has made it possible to win and considerably purify streptomycin directly from the whole broth in one step. In other cases we are not so fortunate and more steps are needed.

To illustrate the recovery and purification of fermentation products of this type, a generalized flowsheet is presented in Fig. 3.

PRETREATMENT—

Processers usually must get cell tissue, their product source, out of the way first, like to work directly if they can.

In most processing schemes suspended matter—mainly the cells of the fermentation organism—is removed before any attempt is made to recover the product. The usual procedure is to first treat the broth to coagulate and harden cellular proteins (denaturation), making them more readily filterable. This is done by acidifying and heating. Sulfuric acid is added to pH 2-3, and the batch is heated to boiling, or a little below, for 15 minutes to an hour.

Rigor of treatment allowed depends on the stability of the products. Penicillin is not stable at low pH values so pretreatment of this sort is impossible. Streptomycin, on the other hand, is able to stand these conditions easily.

Broth Pretreatment Eases Processing

Another dividend accrues from the pretreatment of streptomycin fermentation broths. Apparently a portion of the antibiotic is retained within or adsorbed on the cells. Acid treatment liberates this material and makes it recoverable. Similar phenomena are observed with a number of other antibiotics; in each case product losses during heating must be balanced against product pickup from the cell tissue.

Following pretreatment, the broth is filtered to remove coagulated mycelium and other suspended matter. Where it is desired to remove interfering ions (e.g., calcium) previous addition of a precipitant (if sulfuric acid does not satisfy) will provide for this as well.

Both plate-and-frame and rotary filters are used—with abundant quantities of filter aids. For a relatively large-volume product like penicillin, rotary filters are used. For antibiotics which are run in smaller lots, or only periodically, plate-and-frame units are the choice.

Filtration Can Be Slow and Messy

With adequate pretreatment and the generous use of filter aids, reasonable filtration rates (10-20 gph./sq.ft.) can be achieved. Biggest problem is plugging of the filter bed with the slimy cell mass. In a few happy instances (penicillin is the prime case) cell material is fibrous and porous enough to permit ready filtration with only a light pre-coat of filter aid.

Even when no difficulties are encountered, filtration of large fermentation broth volumes is a messy and costly business. Filter aid alone is a major factor in antibiotic recovery costs. Therefore every effort has been made to avoid this step by recovering products directly from the whole broth.

Process Whole Broth Directly if You Can

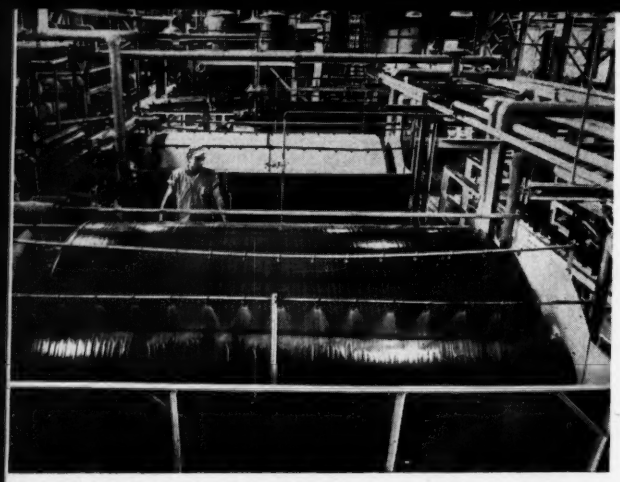
For a long time direct whole broth recovery wasn't attractive. Precipitation and nonselective adsorption could not be used in the presence of heavy cell growth. Passage of whole broths through beds of adsorbants or exchange resins gave rapid "sliming" and plugging.

Solvent extraction was equally unsatisfactory; solids tended to collect in centrifugal extractors and stable emulsion formation was encountered in most cases.

This situation did not long remain, fortunately. Equipment improvements have made it possible to carry out both solvent extraction and ion exchange on unfiltered fermentation broths. Precipitation methods, however, are still restricted to highly-clarified fluids.

Whole broth ion exchange is carried out by first screening the broth to eliminate large particles. It is usually advisable to sterilize broth at this point by adding suitable chemical agents, if bacterial contamination of the resin beds is to be minimized.

Broth with its finely divided cellular matter may



FILTRATION: Big rotaries smooth way (Chas. Pfizer).

now be passed through fixed or fluidized exchange beds, depending on the characteristics of the resin used. Fixed beds are simpler, but plugging is still a problem. On the other hand, fluidized resin particles must be retained in the bed by screens which will still pass the fermentation solids—a tricky business.

Solvent extraction of whole broths is possible with new models of the Podbelniak. Enlarged perforations in the contacting band, more clarifying space at the rotor periphery, an added solids-deflecting baffle, and modified rotor, inlet, and outlet ports—all these changes enable the centrifugal extractor to handle whole fermentation broths containing as much as 10-15% solids by weight. This permits a significant economy in recovery operations.

EVAPORATION—

Concentrating heat-sensitive materials calls for gentle treatment. Thin-film, downflow, vacuum equipment fills bill.

In many process schemes removal of water or an organic solvent is required. Frequently this step is employed only to reduce the volume of the process liquor. Occasionally, however, a concentrate is being handled and evaporation is to be followed by crystallization of the final product.

A variety of low-temperature evaporation techniques are in use, all employing vacuum. In cases where the product is stable enough, high-vacuum operation with low liquid inventory is sufficient to ensure reasonable throughout with low losses. With materials more sensitive to heat, however, this is not so and further pains must be taken.

Thin-Film Evaporators: Fast and Gentle

Perhaps the most valuable development is the use of thin-film evaporators with no liquid head. Long-tube evaporators with the liquid flowing down, but not completely filling, the tubes eliminate hydrostatic fluid head and the attendant boiling point elevation.

High capacities with very low liquid retentions, and good steam economy are claimed for these units. Their use for concentrating heat-sensitive biochemical materials has proven quite satisfactory.

It is also possible to combine evaporators of this type with refrigeration or mechanical vapor recompression systems to give even lower temperatures.

A further development of the thin-film evaporation scheme employs mechanically driven rotors to distribute the process liquor in a thin, turbulent layer (Fig. 4). The downflow principle is again used to avoid fluid head.

Evaporators of this type (Rodney-Hunt's "Turba-Film" and Buflovak's "Roto-Vak" are examples) handle very high evaporation loads with liquid inventories less than 10% of those of conventional designs. Applications include a wide range of biological and other complex organic mixtures.

Freeze-Drying: Safest Concentration

While drying, as such, need not be included in a discussion of methods for separating and recovering solution components, still one particular technique deserves mention. For many biochemical materials (enzymes, for example) freeze-drying or low-temperature sublimation gives reliable, effective concentration.

The method depends on the fact that, over a wide temperature range, the vapor pressure of ice is high enough to permit rapid sublimation. Material to be concentrated is first frozen as a thin film in a pan or along the walls of a cylindrical container. Baths of dry ice and some suitable solvent are used to obtain the needed temperatures. Cylinders may be rolled mechanically to develop the film.

The container of frozen solution is then placed in or coupled to a vacuum system with a cold-trap. A vacuum is drawn and subliming vapor is collected on the cold surface and removed intermittently.

Molecular Stills Vs Low Volatility

Distillation is little employed for the direct separation of biochemical materials. Its main role in this business is the recovery of solvents used in other processing schemes. One limited exception is molecular or "high-vacuum, short-path" distillation.

Here the vaporization surface is brought extremely close to the condenser in a very high vacuum. Molecules leaving the liquid surface may then reach the condenser without colliding with other molecules.

Development of this technique has made possible the separation by distillation of many complex high boiling liquids. In biochemical processing, however, molecular distillation's role has been pretty well limited to vegetable, fish, and animal oils and to the purification of vitamins A and E. Most biochemical materials exhibit too low a volatility even for this type of recovery.

ADSORPTION—

Heading the list is ion exchange which can demineralize, neutralize, selectively adsorb, interchange—even sort by size.

Solid adsorbents (activated carbon, clays, etc.) are widely used for the recovery of soluble materials but they rarely seem to be the method of choice. Their selectivity is, in general, too low, although it is usually possible to remove the product from solution.

Furthermore, adsorption is frequently not fully reversible and product is lost through failure of the eluting agent to completely recover it from the solid. In general, non-selective adsorbents of this type are

more suited to the removal of miscellaneous impurities than to direct product recovery.

Adsorptions may be carried out batchwise or in fixed beds. In nonselective treatment with carbon, fuller's earth, etc., fixed-bed operation is out because of the small particle size of the adsorbent. Adsorbents of this type may even be discarded after a single use because recovery is such a messy proposition.

Even so, practically every antibiotic manufacturing process has at one time or another included carbon adsorption recovery. The method, though not so neat and specific, is reliable and relatively gentle.

Carbon adsorption techniques were first used in penicillin manufacture but they have given way completely to solvent recovery. The strong ionic character of penicillin suggests some resin exchange process but so far none has been reported. Very low stability of the acid is probably the limiting factor.

Chromatography: Unproved Potential

Chromatography, essentially a means for countercurrent adsorption, has been largely restricted to analytical and pilot-scale separations but its potential value in commercial processing is very great.

In chromatography a mixture of strongly adsorbed substances is fractionated by virtue of differences in the relative affinities of the components for the solid adsorbed.

Separation is actually achieved by passing a solvent through a bed on which the mixture is adsorbed. A continual process of desorption at one point followed by adsorption further on takes place. The most weakly adsorbed component moves fastest and is gradually segregated. In this way a number of zones, containing individual, more-or-less-pure components of the mixture, are obtained. This is the "chromatogram."

Chromatographic adsorption will obviously be an intricate and expensive operation for large-scale use. So far its drawbacks have not been overcome.

Ion Exchange Heads Selective Adsorption

The use of ion exchange resins has revolutionized recovery techniques. Basically a method for selective adsorption, ion exchange offers a really effective tool for processing biochemicals, mainly because of the diversity and improved properties of currently available exchange resins.

Ion exchange may be used in a number of ways in processing biochemicals. Most important of these are:

Deionization and Demineralization—salts or individual ions may be removed. Desalting of proteins and the removal of metal contaminants from pharmaceutical preparations (vitamin B_{12}) are good examples. For applications of this sort, strong exchange resins (sulfonic and quarternary ammonium types) are used, either in mixed beds for deionization or individually for the removal of specific components.

Neutralization—removal of excess acids or bases after the hydrolysis of amino acids, for example. Generally the weaker resins—amine types for acid neutralization—are used. Such a process does not represent true ion exchange but rather a kind of "chemisorption" of the strong acid on the weakly-dissociated resin base.

Ion Interchange—replacement of one ion with another. Examples: exchange of the hydrochloride for the hydrobromide complex in thiamine (vitamin B_1); preparation and formation of potassium penicillin and calcium pantothenate from the corresponding sodium salts. Ion interchange has found much favor in biochemical processing because it helps to avoid the mechanical losses forever attendent on repeated precipitations and dissolutions.

Adsorption-Elution—this is a variation of the neutralization technique involving solutes of higher molecular weight. The antibiotic streptomycin can be adsorbed onto a weak cation exchange resin (carboxylic type)—essentially a neutralization of the basic antibiotic by the weak resin acid. Recovery of the adsorbed material is accomplished by treatment (elution) with a strong acid.

Exchange techniques may, then, be employed for recovery of products, the removal of undesirable impurities, and for the modification of product forms. Furthermore, resins can be used to fractionate a mixture on the basis of different exchange equilibria between the components (ion exchange chromatography).

A number of innovations in ion exchange practice, arising from the peculiar features of biochemical technology, have been suggested. One is exchange from solvent-water mixtures. (The resin used must

Thin-Film Downflow Evaporator

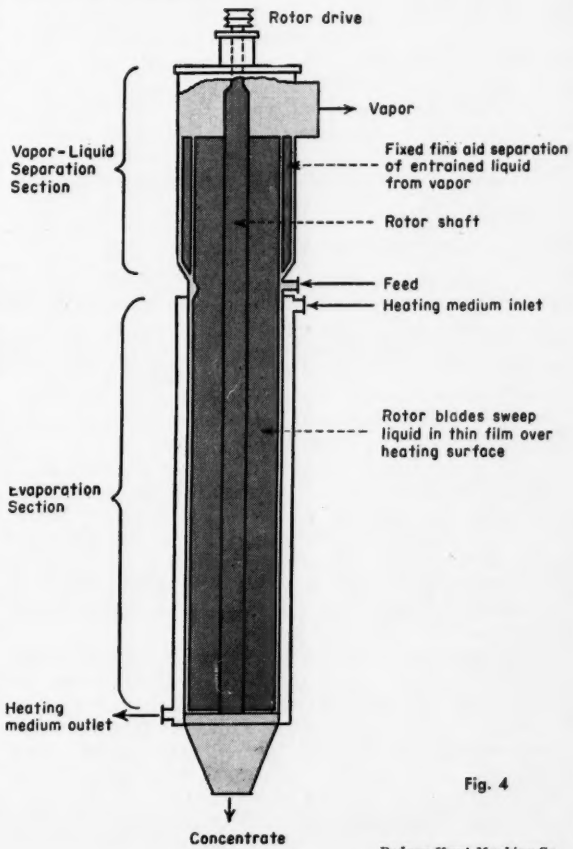


Fig. 4

Rodney Hunt Machine Co.

not, of course, be subject to attack by the solvent.)

Exchange Resins Sort by Molecular Size

Another innovation is the use of resin beds to separate substances according to molecular size as well as ionic activity. With resins of low porosity, ions and small molecules are able to penetrate the polymer matrix and exchange with internal active sites while larger molecules are restricted to surface sites.

This technique—a type of ion-exclusion—permits the recovery of an ionically-active material from solution with simultaneous separation of metal ions and low molecular weight impurities, all in one bed. The surface-adsorbed component may be washed free with a weak eluting agent, leaving the internally exchanged impurities in the bed.

Ion exchange has proven particularly effective in the separation of amino acid mixtures and in antibiotic recovery. It has, like any adsorption, most of the limitations of fixed-bed operation, but techniques for overcoming these are being developed. Use of fluidized beds is one of these techniques.

Amino Acid Recovery via Ion Exchange

Method of choice for amino acid recovery and fractionation is ion exchange. By selecting a group of resins with different characteristics and adjusting the pH of the mixture between steps, it is possible to separate a typical protein hydrolyzate into several groups of amino acids. It is even possible in some cases to fractionate further into individual acids.

In this discussion attention has been pretty well confined to separation of the components of amino acids and protein mixtures. Many other problems exist other than fractionation alone. In processing blood plasma it is necessary to remove salts, metal ions (calcium must be eliminated, for example) and many other constituents. For these purposes ion exchange has proven exceptionally useful.

Exchange Keys Streptomycin Processing

Ion exchange recovery of fermentation products can be thought of as neutralization with an insoluble acid or base of extremely high molecular weight. Probably the most attractive feature of ion exchange is that volume reduction and a considerable degree of purification can be effected in one step. Furthermore, it is possible, as we have seen, to handle the whole fermentation broth in many cases.

Streptomycin processing is the classical example of ion exchange recovery of an antibiotic (p. 247). Following pretreatment with acid and heat the broth is sent to columns containing weak cation-exchange resin of very high capacity (Amberlite IRC-50 and equivalent grades are favored). Streptomycin is a moderately strong base, forming an adsorption complex with the weakly acidic resin.

Elution of the adsorbed streptomycin with HCl follows and is very complete. This acid eluate can be concentrated by evaporation after which methanol is added to precipitate inorganic salts. At this point the streptomycin preparation is already quite pure chemically but further refinement is necessary for medicinal use.

Precipitation of streptomycin as a calcium chloride complex, resolution and precipitation as the sulfate from methanol follow. A final resolution and "biological filtration" of the product to remove suspended matter precedes packaging.

PRECIPITATION—

A simple separation method—but only as precise as the precipitant, be it electrolyte, complexing agent or modifier.

It is interesting to note that the most useful techniques for separation and recovery of biochemical mixtures are those which involve the addition of one or more components to the original mixture. A new phase results: solid or liquid, richer in the desired product.

Another common procedure which should be noted is selective chemical precipitation. This method has been very much used for antibiotics and a variety of other fermentation products.

If a precipitant or complexing agent specific to the product can be found, recovery becomes a simple, if not a particularly neat, procedure. Precipitated material must be filtered free, washed, and broken up chemically to liberate the desired component.

Still another variation on the precipitation scheme is use of solvent modification. One can, for example, alter the electrolyte concentration in a solvent used to dissolve a complex mixture, various components precipitating within particular concentration ranges. This is in fact the time-honored method of protein fractionation, with ammonium sulfate the main precipitant.

Hydrotropes Aid Protein Fractionation

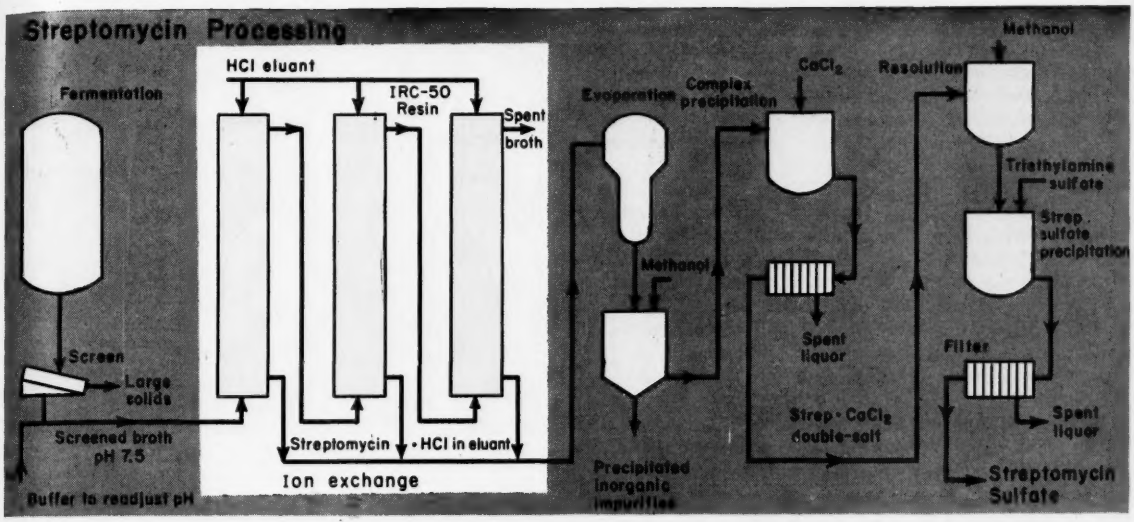
Hydrotropic solvents (hydrotropes) offer another attack on complex mixtures. Broadly defined, a hydrotropic solvent is an aqueous salt solution capable of dissolving more of a particular material than does water. By diluting the hydrotrope, then, precipitation may be caused. Typical hydrotropes are the neutral salts of organic acids: sodium benzene sulfonate and sodium cymene sulfonate.

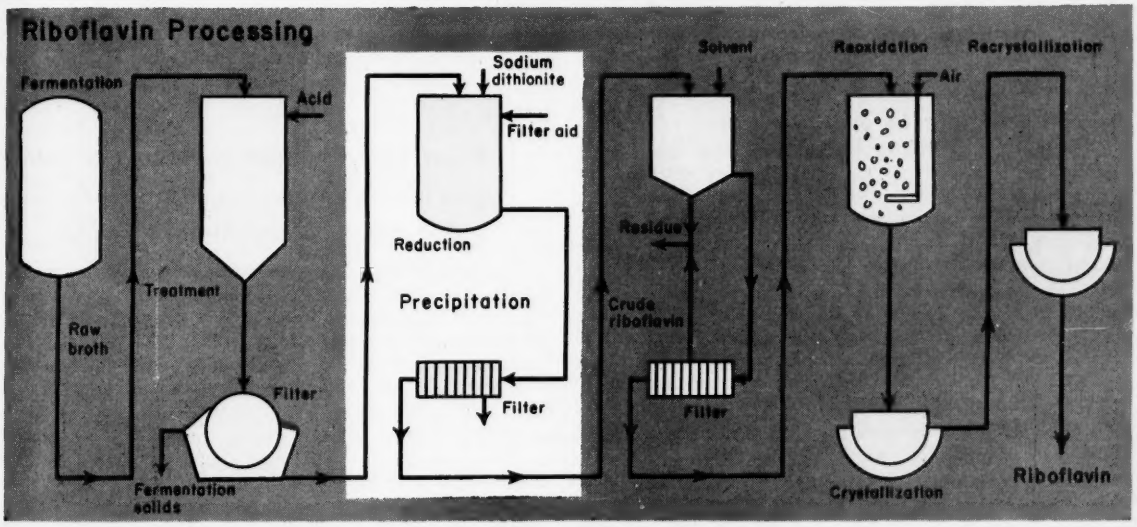
Hydrotropes will dissolve proteins, cellulose, and many other high-molecular-weight natural polymers not readily soluble in water. Mixtures of these materials can be fractionated by dilution of their hydrotropic solutions, a procedure very similar to ammonium sulfate precipitation. No extensive commercial use of this phenomenon seems to have been made, however.

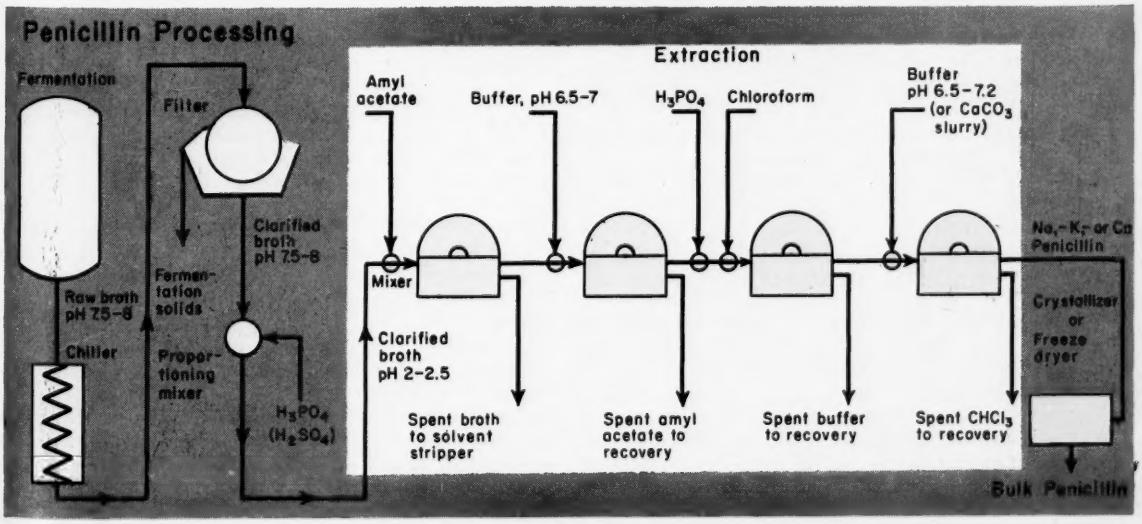
Electrolytes Selectively Precipitate Proteins*

Ammonium Sulfate	Protein Fractions Precipitated	
(% of Saturation)†	% Each Time	Class
34	20	Mostly γ–globulins
40	15	α–, β–, γ–globulins
50	14	α–, β–globulins
62	32	Crystalline albumins
68	14	Albumins, etc.
100	5	Residue

*From horse serum; †4.12 moles/liter


Streptomycin Processing
Fermentation
Screen
Large solids
Screened broth pH 7.5
Buffer to readjust pH
HCl eluant
IRC-50 Resin
Spent broth
Streptomycin
HCl in eluant
Ion exchange
Evaporation
Complex precipitation
$CaCl_2$
Methanol
Spent liquor
Strep · $CaCl_2$ double-salt
Precipitated inorganic impurities
Resolution
Methanol
Triethylamine sulfate
Strep. sulfate precipitation
Filter
Spent liquor
Streptomycin Sulfate


Riboflavin Processing
Fermentation
Acid
Raw broth
Treatment
Filter
Fermentation solids
Sodium dithionite
Filter aid
Reduction
Precipitation
Filter
Solvent
Residue
Crude riboflavin
Filter
Reoxidation
Air
Recrystallization
Crystallization
Riboflavin


Penicillin Processing
Fermentation
Filter
Clarified broth pH 7.5-8
Raw broth pH 7.5-8
Fermentation solids
Chiller
Proportioning mixer
H_3PO_4 (H_2SO_4)
Extraction
Amyl acetate
Buffer, pH 6.5-7
H_3PO_4
Chloroform
Buffer pH 6.5-7.2 (or $CaCO_3$ slurry)
Mixer
Clarified broth pH 2-2.5
Spent broth to solvent stripper
Spent amyl acetate to recovery
Spent buffer to recovery
Spent $CHCl_3$ to recovery
Na-, K-, or Ca Penicillin
Crystallizer or Freeze dryer
Bulk Penicillin

Electrolytes Precipitate Proteins

Electrolyte precipitation is probably the most important technique for protein fractionation. A typical fractionation of the proteins of horse serum by ammonium sulfate precipitation is shown on p. 246. Separation is certainly not clean cut but the procedure is simple and easy to carry out.

Many proteins are separated from natural sources, like plant and animal tissue, by simply dissolving them out with a solvent. Selectivity is generally poor and considerable denaturation may occur.

Organic solvents, like methanol, ethanol, acetone and other light alcohols and ketones, may be used to precipitate proteins from aqueous solutions. Attendant denaturation is usually quite severe and such precipitations must generally be carried out at very low temperatures (0 to −10 C.).

Fractionation of human plasma is actually carried out in this way with ethanol as the precipitant. Cuts are taken over an increasing range of alcohol concentration with results much like those for salt precipitation shown on p. 246. This procedure has been improved by adding small concentrations of divalent cations, like zinc or barium. Lower alcohol concentrations are then possible with less denaturation of the plasma proteins.

Chemical Action Best for Antibiotics

Chemical precipitation of antibiotics has been widely and successfully practiced and a list of the agents used would sound like a catalog. Among the most successful have been:

Large polar dyes—helianthic acid, Congo red, Naphthol Blue-Black, for streptomycin.

Quaternary ammonium compounds for terramycin and similar amphoteric substances.

Acids and bases—lime for aureomycin.

Specific oxidizing and reducing agents—for riboflavin.

The last of these is an interesting case. Riboflavin is not usually recovered from fermentation broths in pure form. More often these broths are simply spray-dried and powdered for use as feed supplements. In this way added nutrient value of other broth components is not lost.

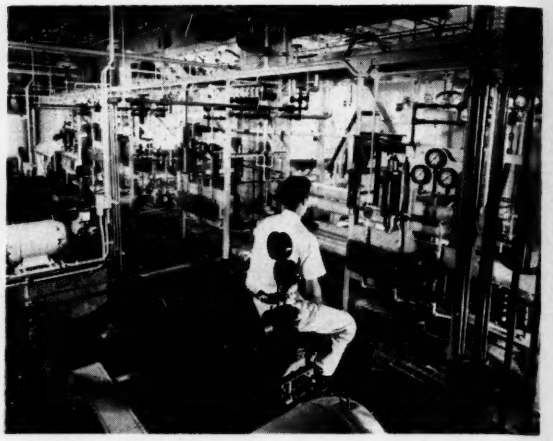
In some cases, however, it may be desirable to recover riboflavin from highly concentrated primary fermentation broths (p. 247).

This is done by taking advantage of the peculiar nature of the riboflavin molecule. Its flavin structure readily undergoes reversible oxidation and reduction, the reduced form being quite insoluble.

A number of reducing methods have been proposed but the best seems to be treatment with sodium dithionite (hydrosulfite), $Na_2S_2O_4$. Well over 90% of the vitamin in the raw fermentation broth can be recovered as a crude precipitate (80-90% pure) by dithionite treatment.

Precipitation in the presence of a suspended filter aid greatly simplifies the procedure. The crude precipitate may then be extracted and the riboflavin reoxidized and crystallized.

Terramycin recovery provides a notable example of the precipitation technique. The antibiotic is precipitated from filtered broth as a quaternary ammonium salt ("Q" salt). This agent is claimed to be so specific that the precipitate may be filtered off and redissolved to give a solution from which a crude terramycin can be crystallized directly. Recrystallization yields a finished product.



EXTRACTION: Spinning contactors work fast (Upjohn).

EXTRACTION—

Centrifugal countercurrent contactors give high throughputs, multiple theoretical stages, low retention of liquid.

Extraction with solvents has proven to be one of the most useful tools for recovering biochemical materials, particularly those of lower molecular weight. In the purification of antibiotics, vitamin B_{12}, etc., extraction and ion exchange share the main load.

Extraction offers a high degree of over-all selectivity through the use of multiple extraction steps with different solvents. Furthermore, the generally-used solvents are not potent chemical agents and so there is little product damage.

Greatest limitation on extraction procedures again seems to be that imposed by the dilute product streams. If the distribution coefficient is not very favorable it will be necessary to use very large solvent volumes.

Another problem is that, in general, the most effective solvents for biochemical materials are also fairly soluble in water—most natural products are polar. This means either loss of large amounts of solvent in the waste stream or expensive solvent recovery.

Extraction: First Choice but Expendable

For these reasons solvent extraction is not favored for primary recovery of a product from fermentation broths. A survey of the literature on antibiotic manufacture shows that solvent extraction is often the first method to be used. This reflects the carry-over of standard laboratory procedures, where the separatory funnel is a handy device, to the production unit. As individual products become more highly developed solvent extraction is discarded in favor of more economical means.

In subsequent purification steps, however, where much smaller volumes are encountered, extraction is

an excellent technique, quite competitive with the others in any particular case.

Penicillin recovery is a notable exception to this generalization. The antibiotic's extremely favorable distribution coefficients between water and a number of cheap solvents make direct extraction of penicillin from fermentation broth a feasible proposition.

High Throughput, Low Liquid Retention

As with evaporation, a number of special extractor designs have appeared which feature high throughputs with low retention of liquid in process. These are particularly applicable to treatment of biochemicals.

Probably the best known of these is the Podbelniak centrifugal extractor (photo, p. 248). In this device feed liquor and solvent are passed countercurrently through the open space within a spirally-wound metal band. Main flow path follows the full length of this band with a degree of short-circuiting and cross-flow provided by perforations in the band.

Forces of several thousand times gravity are obtained by spinning the whole band assembly on a rotor at high speeds. Throughputs of up to 25,000 gph. are possible with liquid inventories of only a few gallons. Performance tests have consistently shown Podbelniak units to have the equivalent of about 3 to 6 theoretical stages in regular operation.

Recent models handle liquids with suspended solids quite readily. This feature is particularly useful in treatment of unfiltered antibiotic broths.

Penicillin: Extraction All the Way

Solvent extraction, despite the limitations noted earlier, has played a major role in antibiotic processing. With the exception of streptomycin, which is too polar to be readily soluble in organic liquids, almost every antibiotic process has employed solvent extraction at one time or another. Penicillin recovery is the classical example.

Electrophoresis: Slow But Sure Separation

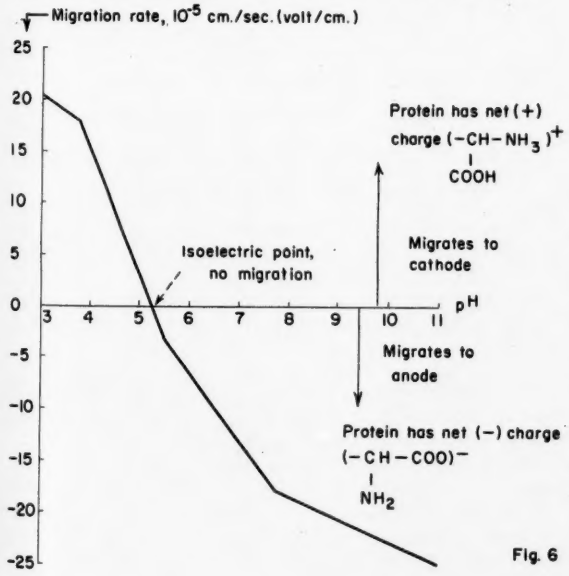


Fig. 6

Penicillin itself is a moderately strong acid but its stability in this form is very limited. In raw, untreated fermentation broth (pH 7.5-8) the antibiotic is quite stable, particularly if the batch is held under refrigeration; only about 10% is lost in 2 days at 0 C. In the free acid form, however, the half-life of penicillin is only a few hours, with decomposition to inactive and therapeutically useless derivatives of penicillin.

As a free acid, penicillin is readily soluble in the common alcohols, ketones, ethers, and esters. It is less soluble in the aromatic hydrocarbons, sparingly soluble in water and insoluble in paraffin hydrocarbons. Of the chlorinated hydrocarbons, chloroform is the best solvent.

On the other hand the sodium, potassium, and calcium salts of penicillin are very soluble in water but virtually insoluble in ether, chloroform and amyl acetate. Penicillin recovery is based on these differences in solubility between the free acid and salt forms.

All solvent recovery processes for penicillin (p. 247) have used three points in common:

High solubility of the penicillin in fat solvents at low pH.

Very favorable distribution coefficients for the free acid between some solvents and water; these range from 25:1 to 40:1, depending on the solvent used.

Holding penicillin in the low pH range for only a very short time.

The Podbelniak extractor has provided the key to the last of these conditions. High distribution coefficients also make possible a great volume reduction —100 fold is usual—along with considerable purification in the first stages of extraction. In subsequent extraction stages, the natural mixture of penicillin is fractionated and the most active component, benzylpenicillin, purified and concentrated (p. 247).

By proper adjustment of conditions, particularly pH, it is possible to obtain such good purification that crystalline penicillin salts may be obtained with little further treatment.

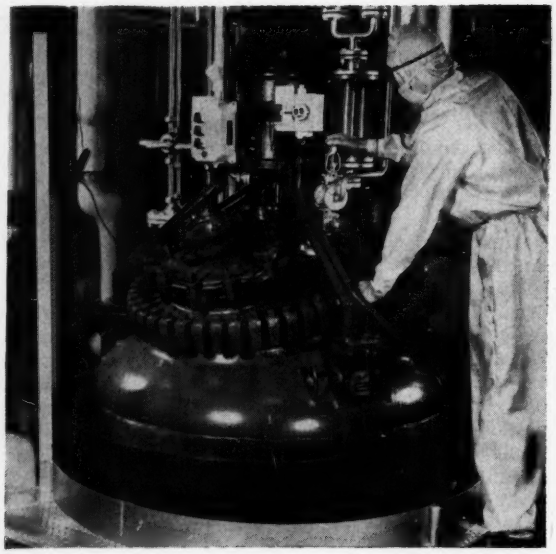
NEW METHODS—

Separations based on electric charge, diffusion rate, molecular size, surface activity pose problems, promise much.

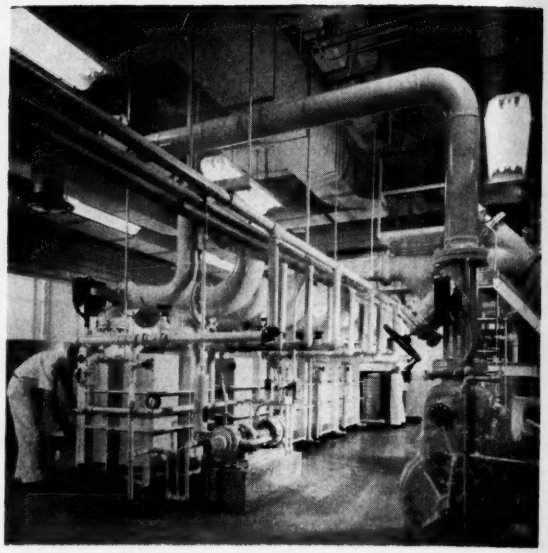
Little commercial application has been made of the remainder of the methods listed on p. 241. Some of these—particularly the ones based on non-uniformity of concentration within a single-phase,—seem very promising. Electrophoresis and dialysis, for example, have been extensively employed in the laboratory. But techniques for handling reasonable production volumes await development.

Electrophoresis: Cations From Anions

Electrophoresis is the movement of charged molecules in an electric field. It is mainly applicable to proteins which exhibit surface charges of varying types and magnitudes, depending on their chemical structure and degree of ionization. Since this last is in turn a function of the pH of the surrounding fluid, a measure of external control is possible.



CRYSTALLIZATION: Finesse is a byword (Chas. Pfizer).



FREEZE-DRYING: Gentlest vaporization of all (Upjohn).

The trouble with electrophoresis is the extremely slow rate of movement toward the electrodes (see Fig. 6). To use this method commercially, extreme inventories would be required and these are simply not practical.

By adjusting the pH of a protein solution, individual components may be left with different net charges. Application of an electric field will then cause these charged components to collect at their respective electrodes. The effect of pH on the electrophoresis of a typical protein, beta-lactoglobulin, is shown in Fig. 6.

Electrophoresis has been used to great advantage to study the structure and fundamental properties of proteins and for the preparation of small amounts of purified experimental material. It is, however, a slow and delicate procedure. Rates of electrophoresis are extremely small, ranging from 2 to 20 ($\times 10^{-5}$) cm. sec. for every volt/cm. of potential gradient (Fig. 6). So far, no unit of reasonable commercial capacity has been reported.

Dialysis: Big From Small

Dialysis is the separation of substances of different molecular size by virtue of their different rates of diffusion through a suitable membrane. Solvents and solutes of small molecular size pass the membrane with ease, while larger molecules do so with difficulty. Dialysis was formerly used to remove metallic and other small contaminants from colloidal proteins and the like, but ion exchange is supplanting it for this purpose.

Apparently it is practical to employ dialyisis for separations only of substances whose molecular sizes differ appreciably—e.g. crystalline from colloidal—if reasonable capacities are to be realized.

Thermal Diffusion: Fast From Slow

Thermal diffusion takes advantage of differences in the relative rates of molecular diffusion under an applied thermal gradient. Its extensive use for the separation of isotopes is well known. The fractionation of carbohydrates and their separation from proteins has also been reported, at least on a laboratory scale.

Foam Fractionation Via Surface Activity

Foam fractionation utilizes the tendency of surface-active materials to concentrate at a gas-liquid interface. When a solution containing such substances is foamed by blowing a gas through it, the resultant froth will be richer in the surface-active components than the original solution.

Proteins and many other biochemical materials exhibit surface activity and so may be separated with varying success by this method. It has been used for the fractionation and purification of enzymes and fatty acids, and for separating carbohydrates and proteins of like molecular weights.

CRYSTALLIZATION—

No other separation method demands more finesse, permits fewer mistakes than this high point in processing.

Crystallization is seldom used as a method for primary recovery, or even gross purification, in biochemical processing. Rather its main role is in the final stages of isolation or recovery where it is employed as a finishing operation on materials already greatly purified.

There are a number of reasons for this. For one, considerable difficulty is experienced in crystallizing many substances directly from raw sources, or even from partially purified concentrates.

Inclusion of closely related compounds and miscellaneous impurities is very hard to avoid. Consequently it is usually necessary to carry purification through several stages before attempting to crystallize this product.

Crystallizability Means Purity

Another point is that many biochemical products are extremely hard to crystallize at all. This is probably due to the presence of minute quantities of impurities; crystallizability has often been used as a criterion of purity for enzyme preparations.

Probably the most important factor of all, however, is the low concentration of the material to be recovered. The volume of liquid is then so great that other approaches are generally more desirable.

For final purifications a number of novel techniques have been reported. Salting of the liquor, not only with organic salts but with other solvents, to reduce preferentially the solubility of desired products is one. Another is crystallization from two immiscible liquid phases; apparently a simultaneous solvent purification results, similar to extractive distillation.

Great care must be exercised in many of these crystallization procedures because they occur in the final stages of purification of materials destined for therapeutic use. Sterile operation is often required, with the crystallizers operated within a sterile processing area (photo, p. 250). Equipment is sterilized by steam or by chemical agents.

As the general flowsheet (Fig. 3) indicates, three major lines may be followed in the processing of antibiotics and similar products of fermentation.

Simplest is the treatment, concentration and drying of whole broth and fermentation solids (cell tissue, unused medium ingredients, etc.), to yield animal feed supplements. Depending on the nature of the feed either spray or continuous belt drying is used. The product is then milled, dry-blended with other ingredients as required, and packaged.

FINISHING TOUCHES—

Therapeutic products—for whom even chemical purity may not be good enough —often undergo sterile processing.

Production of bulk antibiotics and vitamins from fermentation liquors is a far more complicated business. Here the product is a pure pharmaceutical material. It is, however, not necessarily going directly into injectables and other dosage forms, but will be sold to formulators for inclusion in a wide range of specialty products from skin ointments to throat lozenges.

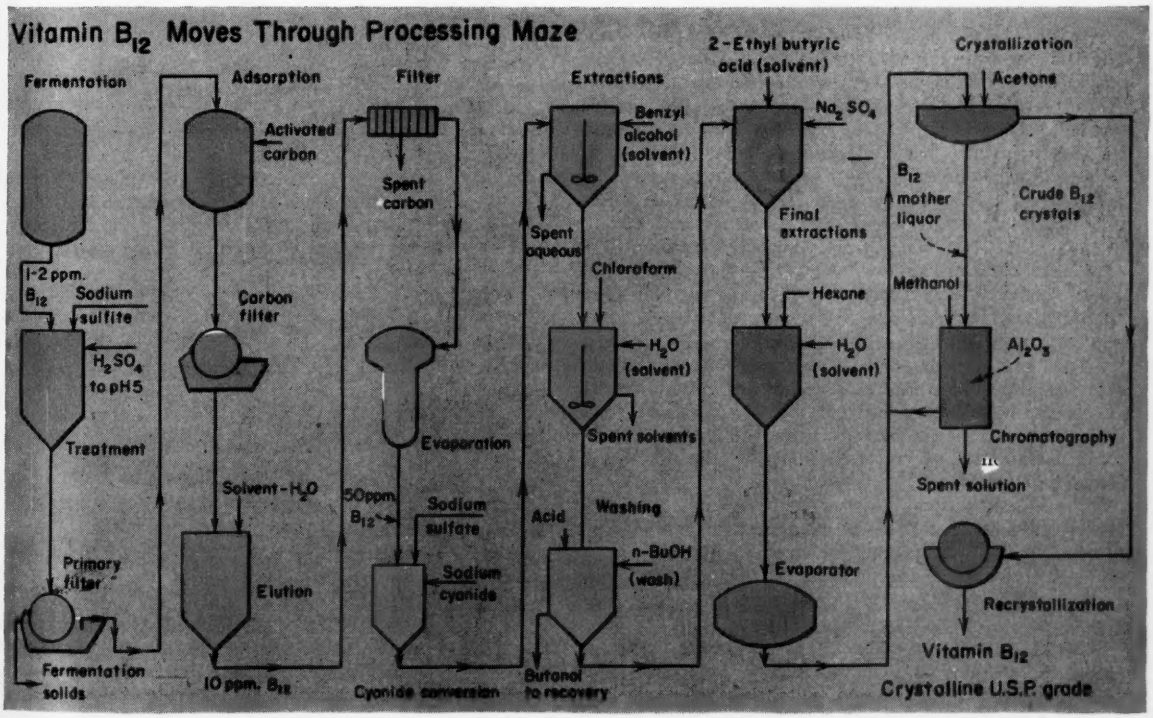
Bulk antibiotics must meet the same basic purity requirements as the finished dosage forms but are not necessarily sterile. For a number of reasons, chiefly consumer preference, crystalline materials are in demand.

Chemical Purity May Not Be Good Enough

The last product line is that leading to regular therapeutic dosage forms, the familiar single-dose antibiotic vial, for example. Here a sterile, as well as pure, product is required and finishing operations are carried out within a sterile processing area.

Final steps in the preparation of both bulk products and packaged materials are generally lumped together in the term "finishing operations." Very little new can be said here, for the procedures used are the ones already discussed, modified and adapted as need be for a particular case.

Certain features of finishing operations in biochem-



ical processing do, however, deserve special mention.

Small Scale Operation—So great is the unit value of these products that final purification steps may handle very small volumes of material. In the preparation of crystalline vitamin B_{12}, the last stages are said to be carried out in conventional laboratory glass equipment.

In any event, the use of specialized low-capacity equipment is common, with strong emphasis on minimizing losses. Special filters, including blown-up versions of the perforated porcelain laboratory type, high-efficiency paper-on-metal units like the Sparkler, and small plate-and-frame presses, are widely used. Glass-lined kettles of 25-50-gal. capacity, bottles, and portable stainless steel tanks are the standard processing units. Drying is often carried out in laboratory-size spray and drum dryers.

Sterile Operations—Where sterile products are needed, the final steps must be carried out under sterile conditions. The sterile area required may cover thousands of square feet, with elaborate precautions taken to insure freedom from contamination. These include continual operation of ultraviolet lights, sterilization of process water by filtration and steam sterilization, steam and chemical sterilization of equipment, and extensive use of guards (cloth bags, steam bleeders, gauze soaked in chemical agents, etc.) on hoses and pipe connections.

B_{12} Process Shoots the Works

Probably the best example of biochemicals processing is the preparation of crystalline cobalamin (vitamin B_{12}) for pharmaceutical use. Only 1-2 ppm. of this agent are found in fermentation broths—a thousand-fold less than the normal concentrations of antibiotics. While not an extremely unstable substance, B_{12} activity may rapidly be lost under a variety of conditions.

Finally, the vitamin is found associated with a great diversity of complex biochemical materials of similar physical properties, as well as a considerable number of simple metallic and organic impurities. There are, in fact, a number of cobalamin compounds; vitamin B_{12} itself contains a cyano group in coordination with cobalt (cyanocobalamin).

Recovery and crystallization of B_{12} from fermentation broth involves a remarkable number and variety of individual separation processes. These are outlined on p. 251, a flowsheet based on available information, mainly patents. The scheme shown quite possibly does not represent real practice in any current manufacturing operation but it does offer a type case.

After heat-treating and filtering the broth, cobalamin activity and almost all other organic matter is adsorbed on activated carbon. The carbon is filtered free and the vitamin eluted from it by solvent-water combinations to give a solution of about 10 ppm. concentration.

No Crystals Without Cyanide

After evaporation to about five times this concentration, the solution is treated with sodium cyanide. This converts the various B_{12} fractions present to the desired cyanocobalamin which will crystallize.

With B_{12} activity in the required form, the solution is salted (Na_2SO_4) to reduce cobalamin solubility and extracted with benzyl alcohol. The activity is then reextracted into water following dilution with chloroform to reduce miscibility of aqueous and organic phases. (Diethylacetic acid is also said to be a specific extractant for the vitamin, and several others have been suggested.) This extraction-reextraction procedure may be repeated for greater purification.

The final aqueous solution is then acidified, washed with *n*-butanol to remove acidic organic impurities and extracted with 2-ethylbutyric acid. After diluting this solvent with hexane, cobalamin is reextracted into water and the aqueous solution concentrated by evaporation. Vitamin B_{12} is then crystallized by the addition of acetone.

To recover B_{12} activity remaining in the mother liquor, it is passed over an aluminum oxide column and chromatographed with methanol. Purified eluate from this column is recycled to the crystallizer. Ion exchange apparently can be used here instead of chromatographic treatment. Crystalline, pharmaceutical grade B_{12} is produced by a final recrystallization.

Many other schemes have been suggested but all involve equally detailed and laborious sequences of process steps. Direct adsorption of the vitamin from the fermentation medium on a weak cation exchanger at pH 3-6, followed by elution with a water-organic solvent mixture has been reported. To what extent this and other selective adsorption techniques are practiced is not known.

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Here, leading experts tell why maintenance looms large on today's industrial scene, and how it offers you opportunities to save money and boost profits.

Maintenance Jumps Into Major Role

We're convinced that this trend raises new problems for today's chemical engineer, so we plan to expand coverage of maintenance in future issues.— Editor

EDITORIAL STAFF

OVERNIGHT, it seems, industry has assigned a major role to maintenance. What has happened to bring maintenance more than the customary curt nod from top management?

Briefly, the tremendous upsurge in mechanization of process industries, and of all industries, has brought with it a sharp increase in investment per employee. More equipment per employee—and more expensive equipment—has greatly increased the burden on maintenance.

All of this means that a greater proportion of every production dollar must now be allotted to maintenance to assure full utilization of equipment together with peak performance and maximum return on investment.

National Viewpoint

As seen by L. C. (Jack) Morrow, consulting editor, Factory Management & Maintenance magazine in his kickoff address at the 8th Plant Maintenance & Engineering Conference, Cleveland, Ohio, January 28-31, 1957:

- The job to be done by maintenance is bigger than ever.
- There are too few people to do the maintenance job.
- The maintenance job is not being done as well as it should be.

To estimate the size of the maintenance job, Morrow examined McGraw-Hill's year-end forecasts of capital expenditures by manufacturing industries. According to first-hand reports from the manufacturing companies, capital equipment expenditures will be 14% higher in 1957 than they were in 1956. And 1956 marked an all-time high.

Industry's capital equipment is cared for by maintenance and the amount of existing equipment determines the size of the maintenance job. So, with capital expenditures reaching a new peak, maintenance faces its biggest job.

Except for the building trades, industrial maintenance work claims a bigger share of the nation's skilled workers than any other type of occupation.

According to the U. S. Dept. of Labor, 250,000 men must be added to skilled labor's ranks each year just to replace losses in the 9-million total due to death, retirement and transfer. Only 100,000 are forthcoming from training programs and immigration. The 150,000-man shortage must be alleviated from other sources

If enough workers are not being trained to keep the skilled force from shrinking, how can there be enough maintenance workers to meet the increased demand created by the greater amount of capital equipment? It's easy to see that there are too few people to do the maintenance job.

Maintenance Lags Nationwide

How well is the maintenance job being done? As an indication, Jack Morrow presented some figures from a report prepared by a consulting firm.

Forty plants, with maintenance costs between $\$\frac{1}{4}$ and $\$1\frac{1}{2}$ million annually, were examined. Here is what they found:

- Every plant checked was handicapped by a complete lack of trained maintenance engineers. Only one had a man with formal engineering training in charge of maintenance.
- Plants in 85% of the cases either didn't budget maintenance expenditures or did so ineffectively.
- All but two of the plants awarded construction and repair contracts without asking for competitive bids. In one half of these cases, purchase orders were issued after the work had been completed.
- No storeroom record system worthy of the name was kept by 75% of these plants.
- Maintenance employees in four out of five plants were found to be idle 20% of the time.
- In 6% of the cases, maintenance supervisors and foremen were found to be much less effective than corresponding foremen in production departments.

While these results did not come from a scientifically and statistically balanced sample, the consulting firm feels that they are representative of the national picture. Even if not representative, Morrow feels that they are serious enough to warrant alarm and are proof that the maintenance job is not being done as well as it should be done.

Company Viewpoint

Now that we've glimpsed the over-all picture briefly through the eyes of Jack Morrow, let's narrow our field of vision down to a specific company.

Speaking before the same Plant Maintenance & Engineering Conference in Cleveland, O. S. York, E. I. du Pont de Nemours & Co., Inc., Wilmington, Del., outlined how the maintenance problem has changed in Du Pont and how the company has approached it.

Over the past 15 yr. the increasing complexity of modern processes and equipment has placed an ever-increasing responsibility on the maintenance forces. As a result, every maintenance head has

watched maintenance cost increase steadily. Many company executives have viewed this increase with alarm.

Everyone has been on the lookout for new and better techniques which can be used either to reduce or control these costs. Therefore, many effective improvement programs have been initiated over the years.

Despite these improvements, a reliable source reports that the cost for maintaining this country's industrial facilities increased 9% in 1956, an amount in excess of $1 billion. The same source expects this cost to increase by at least another 10% this year.

Du Pont Co. with its broad scope of operations may be considered representative of the chemical and petroleum industry. Today, Du Pont feels that the maintenance problem is changing in magnitude, in character and in significance.

Job Grows Larger

At Du Pont the maintenance problem is changing in magnitude as the company grows. Du Pont expects increased costs to maintain plants and facilities represented by an ever-increasing operating investment. Also reflected in mounting costs are the problems of maintaining product quality and continuity of operation for the complex equipment in our continuous processes.

Changing employment patterns are enlarging the maintenance problem. An example of this is the Du Pont Co.'s experience over the past 15 yr. as shown by the curve, p. 255.

Since 1940, company wage-role personnel have increased in numbers to 150% of the 1940 level. If the total number of maintenance employees is extracted from this curve, the total of all other categories has risen to only 125% of the 1940 level.

Now, look at the maintenance labor curve for the same period and notice how the maintenance labor wage role has increased to approximately 270% of 1940. So you see that the maintenance-labor roll in the Du Pont Co. has grown more than twice as fast as all other wage rolls.

As the company grows and processes become more complex, Du Pont expects this trend to continue. Thus, in the next 10 yr. the number of maintenance mechanics may increase another 50% to widen the lead over the other categories still further.

Today's Problems Are Different

Rapid progress in technology of equipment such as instruments and controls is changing the character of the maintenance problem. To see how this has affected the Du Pont Co., let's review once again the 15-yr. period, 1940-1956.

How rate of increase in instrument investment compares with rate of increase in permanent investment is shown on the second chart, p. 255. Although permanent investment has increased very rapidly, you see instrument investment has increased even more rapidly. Since 1940, investment in instruments has risen 500% in Du Pont plants.

The maintenance problem will also change in character with the increasing difficulty of maintaining the operation of the mechanical plants. This problem is shown graphically also.

With a batch process, a component reliability of 90% usually meant that the process was 90% available. As the processes became semi-continuous and more components were tied together to form the over-all process, over-all reliability decreased even though the same 90% component reliability was maintained.

For example, when 10 components with individual reliabilities of 90% are connected together, the over-all reliability of the process may drop as low as 35%, depending upon the frequency and elapsed time of outage.

Likewise, in approaching the continuous process, many additional components have to be tied in to form the complete process. Assuming now that the reliability of individual components has been increased to 95%, with a 50-component process the over-all availability of the system may decrease to 10%, depending on the frequency of outage. This emphasizes the need to improve component reliability above 99.8% in order to operate the continuous process economically.

The significance of the maintenance problem changes as maintenance exerts a greater influence on profits and return on investment. With continued development of automatic controls, we are approaching closer to the continuous plant that has minimum process hold-up time. Therefore, it becomes more and more important to operate the plant with minimum outage and high quality production.

The maintenance head today must concern himself with the total mill cost of the product. Whether the maintenance cost goes up or down is not as important as to know that mill cost is being lowered and high production quality maintained. Only in this way can the maintenance head insure a return on investment and profits for his company.

Plant Viewpoint

Just how the maintenance function can evolve to meet the changing requirements of a modern plant was disclosed recently by P. S. Skaff, Mechanical Superintendent, Du Pont Sabine River Works, Orange, Tex.*

The Sabine-River Works is the first major postwar Du Pont plant and is one of the company's largest. Covering over 1,000 acres, the plant has been growing continuously. A major construction organization has been working continuously at the plant site since 1945.

Operating force at Sabine River totals a little under 1,800 and the mechanical organization comprises 47% of this. The number of maintenance people exceeds the production force by 23%.

Products include methanol, polyethylene and refined nylon intermediates. At the end of 1955 the production level was the highest in the plant's history with the average for the year 25% above the 1954 average. During this 2-yr. period, plant size increased approximately 13%.

Maintenance Can Keep Pace

Against this background what has maintenance accomplished?

In the face of the increased maintenance burden, over-all maintenance costs have been markedly reduced despite materially higher wage rates, material prices and employee benefits.

Ratio of maintenance costs to

* Presented at ASME Petroleum Mechanical Engineering Conference, Dallas, Tex., Sept. 23-26, 1956.

plant investment (replacement basis) has dropped from 5.9 in 1953 to 5.0 in 1954 and 4.3 in 1955. The number of maintenance personnel has been reduced by 126 people during this period. Capital tied up in spare parts and extra machinery has been cut by one third.

There has been no sacrifice in upkeep or in maintenance standards. To the contrary, many improvements have been accomplished. There has been only one major injury in the mechanical group since Nov., 1952, and that was not serious.

This record of economical maintenance was turned in by a maintenance organization that actually is three organizations rolled into one. Each main category of maintenance activity—mechanical, instrument and electrical—has its own administrative and engineering organization.

Total maintenance work breaks down into 78% for mechanical, 15% for instruments and 7% for electrical (see accompanying table). These percentages are based on relative cost, using 1955 experience, and include both material and labor expenditures. Over the past two years, material accounted for about 37% of the total repair bill and labor 63%, exclusive of overhead.

Mechanical Maintenance Totals 78%	% of Mechanical Maintenance
Process piping (excluding insulation)	28.0
Compressors (compression end only)	11.1
Prime movers	5.5
Refining trains	10.0
Pumps, reciprocating	3.1
Pumps, centrifugal	4.1
Insulation	2.6
Painting	4.0
Buildings, general facilities, grounds	5.1
Service headers	2.7
Shops and tools	4.7
Transportation	2.6
Air conditioning	1.5
Design changes and revisions	9.5
Miscellaneous	5.5

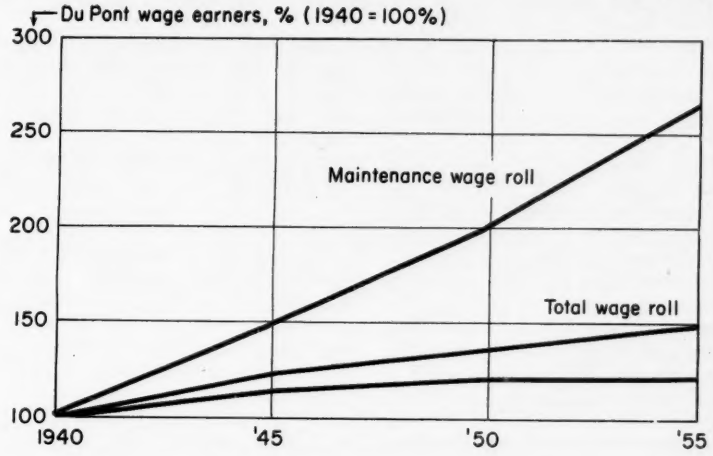
Mechanical Problems Lead

Now then, what are some of the maintenance techniques which enable Sabine River to make maintenance so effective? First, let's look at mechanical maintenance where slightly more than three-fourths of each maintenance dollar is spent.

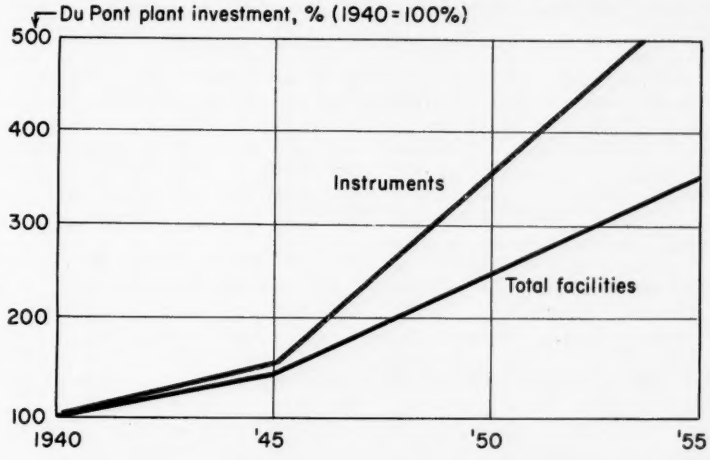
Major elements in the mechanical category are process piping, refining trains and compressors.

An unusually wide range of pip-

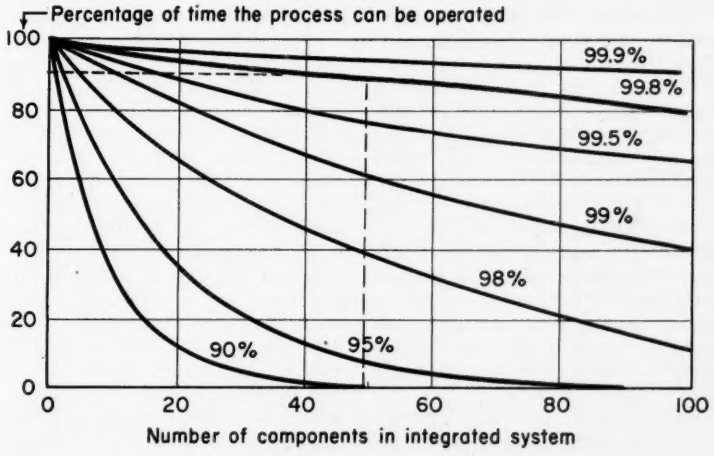
While total number of wage earners has risen to 150% of the 1940 level, the number of maintenance men has climbed to 270% during period.



Growth of instrument installations has far outstripped the rapid growth of Du Pont plant facilities, thereby adding a sizeable maintenance load.



For a 50-component integrated process system to be available to operate 90% of the time, individual components must be at least 99.8% reliable.



ing specifications exists at Sabine River. In such a situation, proper welding and fabrication is extremely important, of course.

Skaff relies heavily on the most modern techniques. To keep welding mechanics qualified for super-pressure work calls for painstaking care and practice.

More maintenance money is spent to keep men qualified for high-pressure welding than is spent on actual repair welding. However, this preventive approach pays off because welding failures have been reduced to a very low level.

In the fight against corrosion, cooler life is extended by metallizing external coil surfaces with a final spray coating of aluminum. Plastic coatings such as phenolic and epoxy resins are now being investigated as replacements for present metallized finishes. Cathodic protection of coils via water immersion has been found quite helpful.

Vibration of piping associated with high-pressure, high-capacity equipment may produce fatigue failure or handicap operation of control instruments. Pulsation dampeners may often correct this condition although it is sometimes very expensive. When this is impractical, maintenance crews have used additional bracing, more rugged supports and isolation from the source of vibration.

Process plugging of still columns on refining trains can become quite disconcerting. The wide variety of gums, tars, scales and scums that settle in columns, condensers and calandrias requires that maintenance devote attention to adequate tools and facilities for cleaning work. Most tube bundles are cleaned at the plant. Outside facilities are used when unusually severe cleaning is needed.

Because Sabine River Works has encountered a number of severe corrosion problems on the water side of refining-train equipment, major attention is devoted to design of tube-sheet venting, location of water baffles, and control of cooling-water temperatures to minimize such attack. Use of a specific stainless steel for condenser tubing may eliminate process attack, but failures can and do occur from stress corrosion caused by chlorides in the cooling water.

Many of the centrifugal pumps have mechanical seals with a total of nine different types of seals in use. At the present time, approximately one seal is changed for every 15 pumps per month.

Progress in performance of mechanical seals results from training mechanics and operators how to install and operate seals properly, continual experimentation with new materials and close engineering followup.

Prevent Instrument Shutdowns . . .

Maintenance of more than 25,000 control units is grounded heavily in a preventive program. To evaluate the benefits of this program, this plant recently conducted a statistical analysis study.

In this study, the probability of shutdown of a large and highly important process unit was considered. The number of probable shutdowns was calculated, based upon normal expectancy of failure of the individual control components and without benefit of preventive maintenance.

Actual shutdown experience with the preventive maintenance program in effect has been less than one per month. Without preventive maintenance, statistical analysis indicated the unit would probably shutdown 26 times per month.

. . . And Electrical Shutdowns

On electrical equipment, it has been found prudent to spend money on organized rather than emergency repair. This is particularly true since Sabine's processes are basically continuous rather than batch. A few hours downtime can easily represent thousands of dollars loss.

To help achieve adequate availability, effort is concentrated on the prevention of insulation breakdowns, faulty or inadequate relaying, overloaded circuits and transformers, lightning surges and bearing failures.

Whenever possible, Du Pont's engineers select only proven components for original installations. In some cases, additional reliability is achieved through detailed reinspection of new equipment.

Insulation levels are checked periodically and corrected. Motors are given special insulation treatment to prolong life between rewinds. At present, motor failures run between 1 and 1½% per year which is considered good in view of the high-humidity conditions.

Maintenance engineers give special attention to fire and explosion hazards. Classification of hazards relating to equipment vs. operating environment is maintained and reviewed periodically.

Everyone Cuts Cost

Success in holding down and reducing maintenance costs at Sabine River Works justifies combining an engineering approach with a sound cost goal program. However, to be effective the cost goals must be established factually and reasonably.

Toward this objective, Skaff describes use of a "job order-account system" combined with machine tabulating and equipment record cards. Through the streamlined job-order and machine-accounting techniques, individualized information is produced promptly in a form readily usable in the field.

With such information readily available and with a good equipment record-card system, realistic cost goals can be established. High-cost equipment elements can be spotlighted easily. Areas of unusual expenditure can be discovered. Then engineering effort can be assigned to solve the problem and reduce cost.

Cost goals in terms of material and manpower are established against each cost account at the beginning of each year, subject to quarterly review in line with changing production forecast. Of great significance is that these goals are set by the individuals who are responsible for expenditures against the accounts.

Performance is reviewed quarterly on a formal basis by both production and maintenance. The people involved make every effort to achieve a favorable cost trend.

Cost meetings are so popular that often the large auditorium must be used to accommodate the crowd. Such "public" reviewing of cost spotlights to everyone the high-cost elements of the plant's activity. When dollar value is applied to each problem, it becomes easy to see where effort should be applied first.

Many cost-reduction ideas that involve both labor and material are generated by the mechanic in the field. These ideas are given without stint because all appreciate that nowadays job security depends largely upon ability to produce efficiently and to remain competitive.

Updating Heat Exchanger Costs

To help you increase the accuracy of your cost estimates, here is up-to-date information on cost of exchangers and tubing.

FRANK L. RUBIN, Downingtown Iron Works Inc., Downingtown, Pa.*

A series of articles was published in *Chem. Eng.* on heat exchanger costs in May, July, September and October 1953. Since then significant changes have taken place in the price of steel and steel alloys.

Using the latest available cost information, we've recalculated some costs as reported in 1953, bringing the data up to date. The new tables should help you in making more accurate cost estimates.

Alloy Heat Exchanger Costs

First, relative costs (not including installation) are shown for a fixed tube sheet heat exchanger with a shell side expansion joint. It can be furnished with either the conventional bare tubes or with extended surface tubing.

Extended surface tubing can readily be installed in heat exchangers in a manner identical to that of bare tubes. Surface increases by a factor of 2.5, while the relative costs for this greater surface are only slightly higher than relative costs for the bare tube unit.

For example (*see table*) in the 24-in. dia. shell, 950 sq. ft. of bare tube aluminum tubing surface cost approximately 10% more than the cost of the all-steel bare tube unit. With extended surface tubing, surface is 2,340 sq. ft., and the aluminum cost is 26% greater than the bare tube steel unit.

Relative costs of alloy fixed tube sheet heat exchangers show very little change from that previously reported for Oct. 1952. The selling price of these heat exchangers was approximately 25% higher in Oct. 1956 as compared to Oct. 1952.†

These fixed tube sheet exchangers are designed for 75 psi. at 500F. Units are furnished with ¾-in. O.D. × 18 BWG ×120-in. long tubes based on a $1\frac{25}{32}$-in. triangular pitch. Construction is in accordance with the 1956 ASME Code for unfired pressure vessels.

Tubes, tube sheets, channel, channel cover liner, and bonnet are of the specified alloy. The shell, expansion joint, baffles, tie rods, spacers and external supports are of carbon steel.

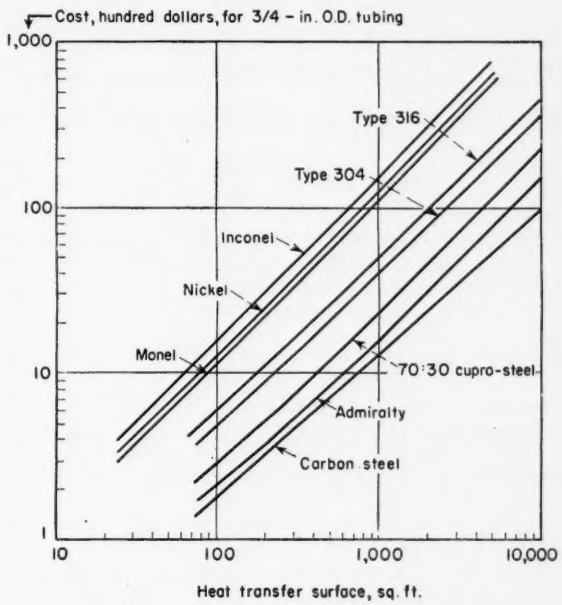
With this table, you can easily estimate the cost of say an exchanger made of copper, provided you have the cost of a steel (or other metal) exchanger.

Tubing Costs for Estimating

Costs of tubing are functions of material, tube diameter, tube wall thickness, quantity, tube length, fabrication techniques.

Quantity is very important in determining price. For example, welded stainless steel Type 304 tubes, ¾-in. O.D. × 18 BWG average wall (for exchanger service in the base length bracket of 4 to 24 ft.) costs

Average Cost of Heat Exchanger Tubing



Relative Costs of Exchangers, Oct. 10, 1956.

For These Alloy Fixed Tube Sheet Heat Exchangers . . .			
Shell O.D., in.	12 3/4	24	36
No. of tubes	126	486	1,176
Baffle pitch, in.	6	12	18
Relative Costs for ¾-In. O.D. x 120-In. Tubing Are . . .			
Surface sq. ft.	250	950	2,300
Steel	1.00	1.00	1.00
Aluminum 3 S	1.13	1.10	1.04
Copper	1.42	1.45	1.58
70–30 Cupro-nickel	1.62	1.68	1.82
Type 304 stainless steel	1.77	2.08	2.15
Ampco 8	1.61	1.79	1.95
Type 347 stainless steel	1.96	2.38	2.47
Type 316 stainless steel	2.00	2.43	2.52
Monel	1.95	2.17	2.51
Nickel	2.07	2.33	2.70
Inconel	2.19	2.53	3.00
Relative Costs for Extended Surface Tubing Are . . .			
Surface, sq. ft.	615	2,340	5,550
Steel	1.13	1.19	1.18
Aluminum 3 S	1.19	1.26	1.21
Copper	1.63	1.53	1.88
70–30 Cupro-nickel	2.16	2.06	2.26

* To meet your author see p. 327.

† This compares with a 17% increase in equipment according to the Marshall & Stevens index.

Relative Costs of Alloy Steel Tubing and Plate, Oct. 10, 1956

Steel Types	Pipe and Tube Data		Plate Data	
	ASTM Specification Numbers or Chemical Analysis	Relative Cost	ASTM Specification Numbers or Chemical Analysis	Relative Cost
Carbon steel, open hearth	A-53 Gr. A, ASTM A-179; A-83 Type A; A-106 Gr. A, A-161	1.00	A-285-54T Gr. C, A-201-54T Gr. A	1.00 1.14
Carbon steel, deoxidized Bessemer	A-53 Gr. B	1.00	Not appropriate for plates	....
Medium carbon, open hearth	A-53 Gr. B; A-106 Gr. B; A-210	1.00	A-212-54T Gr. A	1.14
0.5 Mo	A-161, T1; A-209, T1; A-335, P1	1.51	A-204-54T Gr. B; C 0.20 max., Mn 0.90 max., P 0.035 max., S 0.040 max., Si 0.15/0.30, Mo 0.45/0.60	1.86
0.5 Cr-0.5 Mo	A-335, P2	1.80	A-301-54aT Gr. A; C 0.21 max., Mn 0.80 max., P 0.035 max., S 0.040 max., Si 0.15/0.30, Cr 0.50/0.75, Mo 0.45/0.60	1.97
1 Cr-0.5 Mo	A-213, T12; A-335, P12	1.88	A-301-54aT Gr. B; C 0.17 max., Mn 0.65 max., P 0.035 max., S 0.040 max., Si 0.15/0.30, Cr 0.80/1.15, Mo 0.45/0.60	2.00
1.25 Cr-0.5 Mo	A-199, T11; A-200, T11; A-213, T11; A-335, P11	1.97	A-387-55T Gr. C; C 0.17 max., Mn 0.40/0.65, P 0.025 max., S 0.025 max., Si 0.50/1.00, Cr 1.00/1.50, Mo 0.45/0.65	2.38
2 Cr-0.5 Mo	A-199, T3b; A-200, T3b; A-213, T3b; A-335, P3b	2.13	(No comparable ASTM Plate Spec.) C 0.15 max., Mn 0.30/0.60, P 0.025 max., S 0.025 max., Si 0.50 max., Cr 1.75/2.25, Mo 0.45/0.65	2.84
2.25 Cr-1 Mo	A-199, T22; A-200, T22; A-213, T22; A335, P22	2.48	A-387-55T Gr. D; C 0.15 max., Mn 0.30/0.60, P 0.025 max., S 0.025 max., Si 0.50 max., Cr. 2.00/2.50, Mo 0.90/1.10	3.15
2.5 Cr-0.5 Mo	A-200, T4; A199, T4	2.31	(No comparable ASTM plate spec.) C 0.15 max., Mn 0.30/0.60, P 0.025 max., S 0.025 max., Si 0.50/1.00, Cr 2.25/2.75, Mo 0.45/0.65	3.06
3 Cr-1 Mo	A199, T21; A200, T21; A-213, T21; A335, P21	2.55	A-387-55T Gr. E; C 0.15 max., Mn 0.30/0.60, P 0.025 max., S 0.025 max., Si 0.50 max., Cr 2.75/3.25, Mo 0.90/1.10	3.29
5 Cr-0.5 Mo	A-199,T5;A-200,T5;A-213,T5;A335,P5	2.66	AISI 501 mod. and/or 502 mod.	5.42
5 Cr-0.5 Mo-1.5 Si	A-213, T5b; A-335, P5b	2.88	AISI 501 mod. and/or 502 mod.	5.75
7 Cr-0.5 Mo	A-199, T7; A-200, T7; A-213, T7; A-335, P7	3.00	AISI 501 mod. and/or 502 mod.	6.07
9 Cr-1 Mo	A-199, T9; A-200, T9; A-213, T9; A-335, P9	3.83	AISI 501 mod. and/or 502 mod.	7.06
12 Cr	A-268, TP410	7.40	Type 410	7.57
12 Cr-Al Type 405	A-268, TP405	7.40	Type 405	7.99
17 Cr	A-268, TP430	7.74	Type 430	7.71
18 Cr-8 Ni	A-213, TP304; A-269, TP-304; A-271,TP304;A-376,TP304;A312,TP304	8.42	Type 304	9.81
18 Cr-8 Ni, Ti Type	A-213, TP321; A-269, TP321;A-271, TP321; A-312, TP321; A-376, TP321	9.88	Type 321	11.45
18 Cr-8 Ni, Cb Type	A-213, TP347; A-269, TP347; A-271, TP347; A-312, TP347; A-376, TP347	12.55	Type 347	13.18
18 Cr-8 Ni, Mo Type	A-213, TP316; A-269, TP316; A-312, TP316; A-376, TP316	13.79	Type 316	14.39
25 Cr-12 Ni	A-312, TP309	11.83	Type 309	13.27
25 Cr-20 Ni	A-213, TP310; A-312, TP310	16.96	Type 310	16.82

96.3c./ft. for 300 to 499 lineal feet; for quantities of 50,000 ft. or more the cost is 69.3 c./ft.

Average costs for heat exchanger tubing, ¾-in. O.D., are shown on the curves. All tubing is 18 BWG (0.049-in. wall) except for carbon steel which is 16 BWG (0.065-in. wall). Steel, stainless steel and nickel alloy tubes are average wall. Stainless steel tubing is of welded construction. The other tubes are of seamless construction.

For heavier tube walls, multiply these costs by the weight ratios of the two tubes, for an approximation. For other sizes of tubing, variation in cost/lb. is slight. To get approximate values, you can multiply the cost by the weight ratio, and the reverse diameter ratio—fewer linear feet are required for a given tube surface with a larger tube diameter.

Relative Costs of Tube and Plate

Data on relative costs of tubing and plate material only, were shown previously for March 15, 1953. They are now presented for prices on Oct. 10, 1956.

Carbon steel plate data used in this table are based on an increase of approximately 23% over the same plate cost on March 15, 1953. The tubing cost has increased approximately 41% from the carbon steel tubing cost in effect on March, 1953. Costs do not reflect fabrication, or construction difficulties.

Pressure Drop in Stacked Towers

Depends on gas and liquid rates. Typical problems show how to find pressure drop and fluid capacity for these packings. Also how to determine holdup and flooding rates from available data.

MAX LEVA, Consulting Chemical Engineers, Pittsburgh, Pa.*

Last month *Chem. Eng.* Apr. 1957, p. 267, the general aspects of stacked packings were considered. The present article explains the quantitative flow relations for these packings.

Earlier articles in the series presented the characteristics of pressure drop for two-phase flow in dumped-beds. The relations between pressure drop and gas mass flow were plotted. The graph illustrated the conditions existing below the loading zone, in the loading zone and at flooding.

Pressure drop up to the loading zone is essentially proportional to the square of the gas mass velocity. A gradual increase in the slope of the curve occurs with increasing gas velocity. The dumped-bed is then operating in the loading zone. Further increase in the gas velocity results in flooding and here the curve is virtually vertical.

Two-phase flow phenomena in stacked-beds differ to a certain extent from the flow characteristics of dumped packings. The pressure drop curve for irrigated stacked packings shows the respective differences between dumped and stacked packings. These relations are discussed in more detail in connection with flooding in stacked packings.

Data on flow measurements for stacked packings are scarce when compared to the extensive data available for dumped packings. Since stacked-beds are used primarily in large equipment, tests to obtain pressure drop data might involve substantial costs. However, flow data do become available in the course of normal equipment operation, but this information is infrequently published.

Perhaps the most extensive published stacked-bed pressure drop data are those of Molstad, et al.[3] A portion of these data is shown in Fig. 1. They refer to a Drip Point Grid packing under a range of irrigation rates, in both continuous and crossed-flue arrangement.

Comparison of the two methods of stacking indicates that pressure drops are approximately 10 percent higher in crossed-flue arrangement. This small increase is probably due to exit and entrance losses that may prevail with crossed flues. The smaller packings form a greater number of layers per foot of height. As a result the pressure drop is expected to be higher.

For the purpose of correlation it is convenient to reconsider the flow equation for non-irrigated towers:

$$\Delta P = \frac{2fG^2Z(1-\epsilon)^{3-n}}{D_p\phi^{3-n}g_c\epsilon^3\rho_F} \qquad (1)$$

For highly turbulent gas flow that prevails in stacked-beds, the state of flow factor n and the modified friction factor f are essentially constant. For unit height of bed, Eq. (1) becomes:

$$\Delta P = \frac{C(1-\epsilon)}{\epsilon^3 D_p\phi} \times \frac{G^2}{\rho_F} \qquad (2)$$

The expression $C(1 - \epsilon)/\epsilon^3 D_p\phi$ is recognized as the earlier-mentioned bed characterization factor, whereas G^2/ρ_F is a velocity head. The bed characterization factor, henceforth designated by α' is solely dependent on the mechanical properties of the packed bed. In the above form the equation applies only to non-irrigated beds.

From a consideration of dumped-bed two-phase pressure drop, it has been learned that the effect of liquid rate may be accounted for by multiplying the non-irrigated

How the Series Is Organized

Random packed towers
- Gas-liquid systems
- Liquid-liquid systems

Stacked towers
- Gas-liquid systems

Reactors
- Fixed bed
- Moving bed
- Fluidized bed

Nomenclature (Consistent Units)*

C	Constant in Eq. (2)
f	Modified friction factor
G	Gas mass velocity
L	Liquid mass velocity
Z	Bed height
D_p	Equivalent spherical particle diameter
f'	Friction factor in Eq. (5)
g_c	Conversion factor
α'	Bed characterization factor
β	Constant characteristic of packing
γ	Constant in Eq. (4)
ΔP	Column pressure drop
Δp	Pressure drop per unit height
ϵ	Bed voidage
ϕ	Sphericity factor
ϕ'	Correction factor for gas density
ρ_F, ρ_G, ρ_L	Density of fluid, gas or liquid as indicated by subscript

*Specific units are given in text where needed.

* For author biography see *Chem. Eng.*, Jan. 1957, p. 294.

Constants for Pressure Drop Eq. (3) and Packing Data

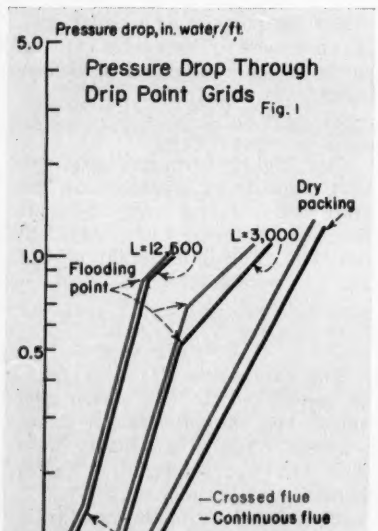
Packing	Pitch, In.	Height, In.	Thickness, In.	Pieces/Cu. Ft.	Voidage, ϵ	Surface Area, Sq. Ft./Cu. Ft.	α'	β
Plain grids	1	1	1/16	....	0.93	25.5	0.007	0.072
	1	1	1/4	....	0.75	30.0	0.021	0.036
	1	2	1/4	....	0.75	27.0	0.013	0.036
Serrated grids	4	4	1/2	....	0.89	6.0	0.005	0.012
	2	2	3/8	....	0.83	13.0	0.009	0.006
	1 1/2	1 1/2	3/16	....	0.89	16.5	0.011	0.030
Ceramic plain rings	4	4	3/8	27	0.73	19.0	0.012	0.035
	3	3	3/8	65	0.66	25.0	0.031	0.082
	3	3	1/4	65	0.76	25.0	0.015	0.055
	2	2	1/4	210	0.67	36.0	0.107	0.064
	2	2	3/16	210	0.72	36.0	0.088	0.064
Ceramic spiral rings	3	3	....	about 60	about 0.62	....	0.150	0.150

bed pressure drop by a correction factor ($10^{\beta L}$). Here L is the liquid irrigation mass velocity and β is a specific constant characteristic of the packing.

If stacked-bed irrigated pressure drops are susceptible to the same analysis there follows for the general case of the irrigated stacked-bed:

$$\Delta p = \alpha' \times 10^{\beta L} \times G^2/\rho_F \qquad (3)$$

New data pertaining mainly to stacked grids and several sizes of plain rings have recently been presented by Morris and Jackson.[4]



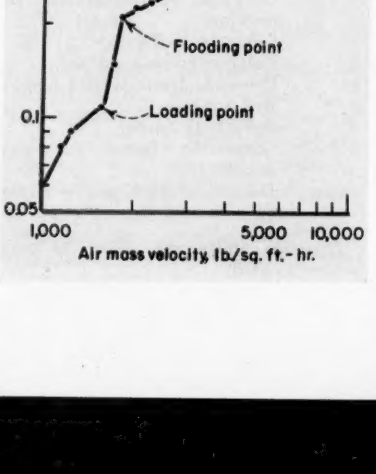
These data, together with measurements from other sources have been used to evaluate the constants in Eq. (3). The resulting values are listed in the table. Mass velocities G and L in lb./sq. ft., sec. are based on the free cross-section of the tower and fluid density ρ_F is given in lb./cu. ft. Pressure drop Δp will then be in in./ft. of packed height.

Norman[5] has investigated the irrigation of Delanium carbon serrated grids shown in *Chem. Eng.* Apr. 1957, p. 268. For air-water flow he correlated pressure drops by

$$\Delta p = \gamma G^{1.8} \qquad (4)$$

In this equation pressure drop Δp is given in in. of water/ft. of packing when G is expressed in lb./sq. ft., hr. Specific constant γ is dependent on liquid rate and has the following values:

Liquid Rate, L Lb./Sq. Ft., Hr.	Constant, γ
0	6.43×10^{-7}
2,000	7.70×10^{-7}
3,000	8.47×10^{-7}



Pressure drop data through wood grid packings have been correlated in a more general way by Johnstone and Singh.[2] They reported

$$\Delta P = \frac{f' Z \rho_F u^2}{2 g_c r_h} \qquad (5)$$

where the friction factor

$$f' = 0.08(4r_h u \rho_F/\mu)^{-0.2} + 0.52(t/a')^{1.5}(4r_h/b)^{0.75}$$

In this expression t is the thickness of the grid members, a' is the clearance between members, b is the average height of the grid members and r_h is the calculated hydraulic radius of the flow section. The velocity u is based on the actual open tower cross-section and μ is the gas viscosity. Note that the equation of Johnstone and Singh does not account for the effect of simultaneous liquid flow.

Problem 1—A tower of 5 ft. inside diameter is stacked with 12 ft. of 3-in. plain Raschig rings. Average ring dimensions are: height = 3 in., outside diameter = 3 in. and wall thickness = $\frac{3}{8}$ in.

The rings are arranged in close packing on a triangular diamond pitch which results in having about 330 rings per cross-section.

The tower is irrigated with water at a rate of 18,000 lb./sq/ft., hr. The gas rising in the tower is essentially air with an average density of 0.075 lb./cu. ft. Its mass velocity is 3,600 lb./sq. ft., hr. What pressure drop should be expected?

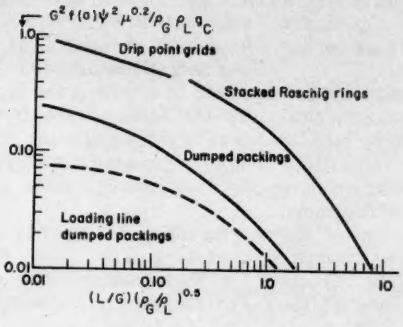
Solution—For this packing $\alpha' = 0.031$ and $\beta = 0.082$. And for this problem $L = 18{,}000/3{,}600 = 5$; $G = 3{,}600/3{,}600 = 1$; $\rho_F = 0.075$. Using Eq (3):

$$\Delta p = 1.07 \text{ in. of water/ft.}$$

The pressure drop through the

Nomenclature for Fig. 3

a	Specific packing surface, sq. ft./cu.ft.
$f(a)$	Packing factor $= a/\epsilon^3$
g_c	Conversion factor, 4.17×10^8 ft./hr.^{2}
G	Gas mass velocity, lb./sq.ft., hr.
L	Liquid mass velocity, lb./sq. ft.,hr.
ϵ	Bed voidage
μ	Liquid viscosity, centipoise
ρ_G	Gas density, lb./cu.ft.
ρ_L	Liquid density, lb./cu.ft.
ψ	Water density/liquid density



Flooding Lines for Stacked and Dumped Packings Fig. 3

packing will be $1.07 \times 12 = 12.8$ in. of water column.

Problem 2—What will the pressure drop be if the above rings are replaced by units with a wall thickness of only $\frac{1}{4}$ in.? Will the reduction be in line with the voidage increase and the effect of voidage on the pressure drop?

Solution—For the new rings $\alpha' = 0.015$ and $\beta = 0.055$. The resulting pressure drop for this packing is 4.6 in. of water column. Hence the replacement of the rings caused a pressure drop reduction of 64%

It is instructive to compare this reduction with the variation in voidage that has taken place. Thus for rings of large wall thickness, the solid cross-section is $330 \times 0.785\ (3.0^2 - 2.25^2)/144$ which equals 7.20 sq. ft. In a similar calculation, the rings of small wall thickness have a solid cross-section area of 4.95 sq. ft.

With a cross-section of the empty tower of 19.60 sq. ft., the voidage values are as follows: for $\frac{3}{8}$ in. wall $= 0.64$ and for $\frac{1}{4}$ in. wall $= 0.75$. These values are in good agreement with the data given in the table.

If in accordance with Eq. (1) pressure drop in the stacked bed may be assumed proportional to $(1 - \epsilon)/\epsilon^3$ then for rings with $\frac{3}{8}$ in. wall $\Delta p = 1.380$ and with $\frac{1}{4}$ in. wall $\Delta p = 0.595$. The reduction is $100\ (1.380 - 0.595)/1.380$ which equals 57%. This value is in fair agreement with the value obtained by using the constants in Eq. (3).

Problem 3—For the conditions of the above problem establish the order of magnitude of the pressure drop as calculated by the Fanning equation:

$$\Delta P = f\, G^2 Z/2 g_c r_h \rho_F$$

The free tower cross-section is 19.60 sq. ft. and the gas mass velocity is 3,600 lb./sq. ft., hr. The solid cross-section of the rings is 7.00 sq. ft. Hence the modified mass velocity is $3{,}600 \times 19.60\ 3{,}600 \times 19.60/(19.60 - 7.00)$ which equals 5,600 lb./sq. ft., hr.

Assuming that for the purpose of calculating the hydraulic radius r_h, the entire surface area of the rings is active. Then the wetted perimeter for the rings is $330 \times 5.25 \times 3.14/12 = 454$ ft. and for the inside of the tower shell $5 \times 3.14 = 15.70$ ft. The total wetted perimeter is roughly 470 ft. Hence $r_h = 12.60/470 = 0.027$ ft.

The value for Reynolds number will then be $4r_hG/\mu = 4 \times 0.027 \times 5{,}600/0.043 = 14{,}000$ where 0.043 is the viscosity of air.

Assume the ceramic material to have a roughness that is in the order of magnitude of commercial steel pipe. Then the friction factor for these rings is 0.008. The Fanning equation (above) gives pressure drop:

$$\Delta P = 1.81 \text{ lb./sq. ft.}$$

The equivalent value is 0.35 in. of water column for the entire tower. This value is obtained for a non-irrigated tower. With an irrigation rate of 18,000 lb./sq. ft., hr., the β factor is equal to 2.58 and the resulting pressure drop would be $0.35 \times 2.58 = 0.90$ in. of water.

Compared with the value obtained from Eq. (3) and based on experimental data, it appears that the value calculated by the above method is outside the proper order of magnitude. The chief reason for this discrepancy is not considering the effect of staggering the rings and exit and entrance losses.

Another and possibly lesser reason may be that the rings, though irrigated, could be substantially rougher than commercial steel pipe. Finally, it may be questioned whether any substantial flow takes place through the spaces between the rings. However, this factor would not affect the pressure drop by a significant amount.

Flooding

The data of Fig. 1 indicates loading and flooding points for a typical stacked packing. The data differ from dumped-bed measurements in two important ways. First—the pressure drop attending flooding in the stacked bed is only about 0.8 in. of water column per ft. of packing as compared with about 2 to 3 in. per ft. of dumped packing. Second—for an increase in gas rate past the flooding point the pressure drop curve does not show the nearly vertical course as is characteristic of dumped-beds.

From the gradual approach of the loading and flooding states in random dumped-beds, it may be concluded that the liquid build-up and hence holdup increases gradually as the gas rate increases. This does not seem to be the case with stacked packings.

As may be seen the irrigated pressure drop lines of the latter resemble quite closely the behavior which is shown in Fig. 2 of ordinary support plates. Thus for gas rates below loading, the pressure drop is essentially proportional to the square of the gas mass velocity.

For the gas flow range between the loading and flooding points, holdup builds up in the vertical

channel. At the flooding point a liquid head develops on top of the stacked packings as well as on the plate.

For further increases in gas rate, the holdup inside the vertical channel does not necessarily have to increase; although the amount of liquid on top of the packing or plate will increase. Owing to the much larger cross section on top of the packing, the rate of hydrostatic head build-up will be slow. Hence the pressure drop rise beyond the flooding point will be more gradual than is experienced in a random dumped-bed where flooding is normally induced by increase in interstitial liquid holdup.

Flooding in stacked packings has not been studied to any appreciable extent. Since stacked beds have high capacities for liquid and gas flow, a considerable investment would be required for such a study. On the basis of the few available data a curve similar to that for dumped packings is suggested. The flooding line for these packings is given in Fig. 3.

In order to use the correlation a packing factor must be specified for the stacked rings and grids. For rings it is suggested that the packing factor be calculated on the basis of the total specific surface area and the prevailing tower voidage. For Drip Point Grids, the total specific surface areas given by Molstad should give conservative gas and liquid rates for which flooding will occur.

As far as other types of grids are concerned there is at the present time no method or correlation by which the limiting capacities of these packings may be predicted.

Loading

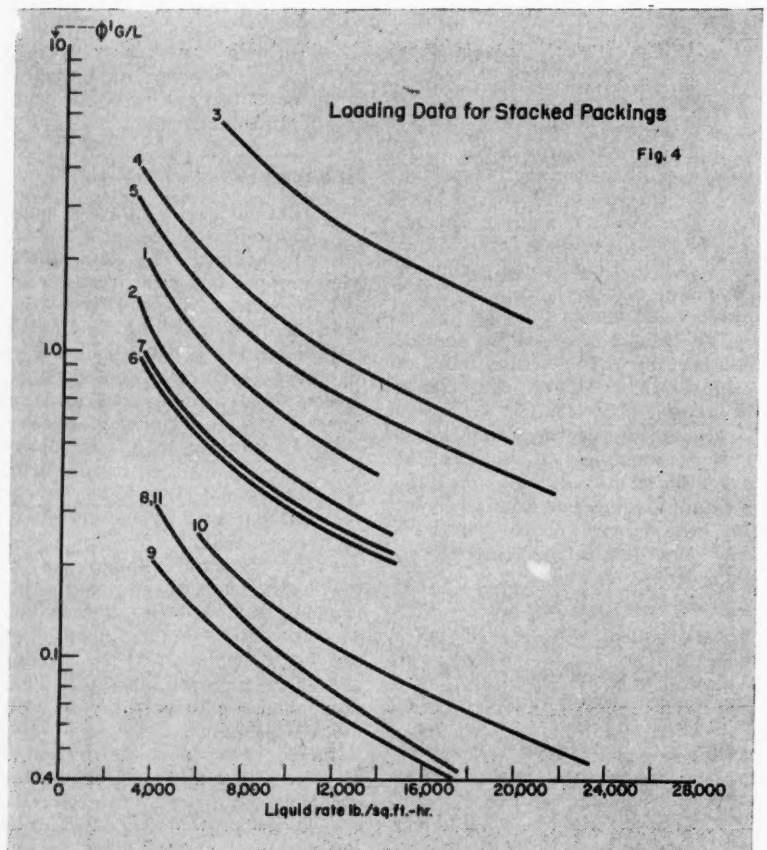
Morris and Jackson[4] have given loading points for a series of grids and a few ring sizes. The data are shown in Fig. 4 in the form of $\phi' G/L$ versus irrigation rate L. Since individual curves are given for each packing, the method eliminates the need of a packing factor.

In the expression $\phi' G/L$, G and L are gas and liquid mass velocities and ϕ' is the gas density correction factor. This factor is defined by $\phi' = (\text{gas density}/0.075)^{0.5}$ where 0.075 lb./cu. ft. is the density of air at standard conditions. The data of Molstad[3] and Fellinger[1] for Drip Point Grids and spiral rings are included in Fig. 4.

The curves of Fig. 4 pertain only to irrigation with water. In practice stacked towers are most frequently used with non-aqueous systems. Examples are acid concentration towers using direct liquid-gas contact, chlorine and general gas drying towers and other systems. The correlations of Fig. 4 as well as the data pertaining to Eq. (3) must be used with caution when liquids are involved whose properties are essentially different than water.

Problem 4—A tower is packed with No. 6146 Drip Point Grids. The irrigation rate is 12,500 lb./sq. ft., hr. What air rate is required to reach loading of the packing?

Solution—From Fig. 4, the value of $\phi' G/L = 0.105$. The density correction factor $\phi' = 1.0$. The gas rate $G = 12{,}500 \times 0.105 = 1{,}320$ lb./sq. ft., hr. This gas rate is in agreement with the value observed from Fig. 1 which shows the original data of Molstad used to construct curve 10 of Fig. 4.



1. Plain grid 1x1x1/16
2. Plain grid 1x2x1/4
3. Serrated grid 4x4x1/2
4. Serrated grid 2x2x3/8
5. Serrated grid 1-1/2x1-1/2x3/16
6. Ceramic plain rings 3x3x3/8
7. Ceramic plain rings 3x3x1/4
8. Stacked spiral tile
9. Dumped spiral tile
10. Grid tile (Molstad) No. 6146 and 6295
11. Grid tile (Molstad) No. 6897

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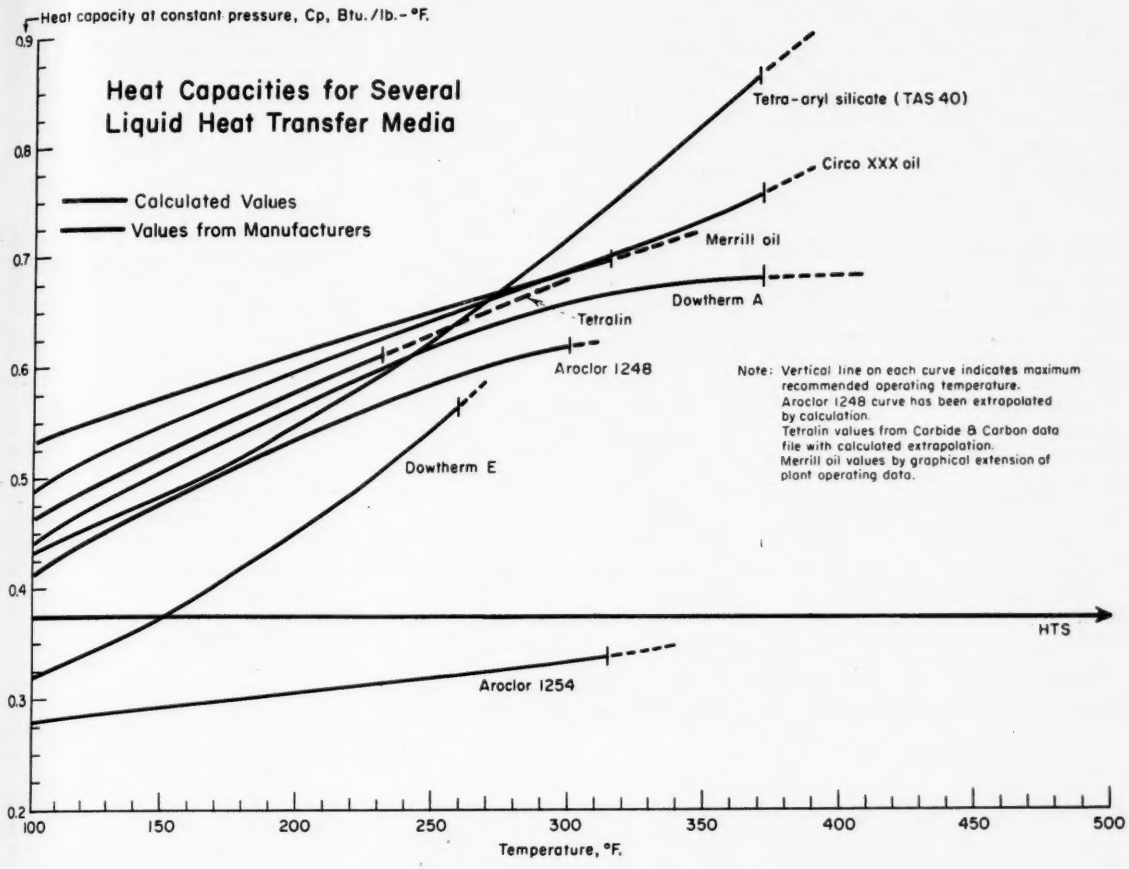


You Can Predict Heat Capacities

Perhaps you have a file crammed full of heat capacities or a competent central research library at your beck and call. If not, here are calculation methods you can use—gathered in one place for the first time.

WALLACE R. GAMBILL, Carbide & Carbon Chemicals Co., Charleston, W. Va.*

Someplace in your elementary or high school career you were asked "How much heat is required to raise one pound of water one degree Fahrenheit?"

It was then that you were exposed to the concept of heat capacity as a fundamental physical property; and you'll be using this concept for the rest of your engineering career.

For heat capacity is a basic tool in all chemical engineering design. Undoubtedly, you have a handy reference file of heat capacity data, or at least you have a good idea of which reference books to go after if you need some data in a hurry.

When these routes fail, here are methods that you can use to estimate this fundamental engineering property.

Thermo Is One Route

Heat capacity is so fundamental to chemical engineering thermodynamics and the possible mathematical relationships are so varied that an exhaustive treatment is beyond the scope of this series. However, we will consider most of the expressions that would be of value to a design or research engineer.

Thermodynamics is but one route to heat capacities. For each of the three states of matter (solid, liquid or gas) heat capacity can be studied and correlated from each of three separate viewpoints or their combinations. They are:

- General thermodynamics.

*Mr. Gambill is now with the Union Carbide Nuclear Co., Oak Ridge, Tenn. To meet your author see *Chem. Eng.*, Feb. 1957, p. 324.

- Molecular kinetics.
- Empirical experiments.

From each of these areas, we can obtain expressions for calculating heat capacity under given physical conditions—and the corrections to be applied for the effects of temperature and pressure.

Exact Thermodynamic Relations

In Table I, below, we have given the general thermodynamic relations that include heat capacity at constant pressure, C_P, and at constant volume, C_V.

To calculate all values of heat capacity—and from these, enthalpy and entropy—we must know, in addition to an equation of state, only C_P at one pressure as a function of temperature or C_V at one volume. In the limiting case of vanishing density, C_P° or C_V° will suffice when available as a function of temperature.

With this information, the procedure is to obtain the appropriate derivatives from the equation of state and then combine them with the equations of Tables I and II to obtain other desired values. The accuracy of the equation of state and of the initially known heat capacity values determine the accuracy of the results calculated for other conditions.

In the numbered sections below, we'll discuss briefly the numbered equations of Table I.

(1) The heat capacity of a substance may be defined in very different ways according to the manner in which the heating (or cooling) is carried out. This equation is the most general definition of heat capacity in that no path is indicated. For the differential coefficients to have meaning, a particular condition is required which will prescribe the direction of change. Heat capacities at constant temperature and pressure are useful examples of such specific conditions, but it is worth remembering that other heat capacities are possible.

When a pure fluid undergoes an isothermal phase change, C is infinite since a finite heat quantity is involved with zero temperature change. Only when the entire fluid has again become homogeneous will the imparted heat produce a temperature rise; and then C becomes once more capable of definition in the usual sense.

Another example would be the heating and pressurizing of a gas at 0 C. and 1 atm. to 100 C. and 100 atm. Compression and heating can take place simultaneously or alternately in a variety of ways, and the total heat absorbed would be different in each case.

Most important heat capacity, other than C_P and C_V, is C_s (of a saturated fluid) which is treated in a following section and in Table II.

(2) At constant pressure $Q = dH$, and C_P results. C_P is always positive and is the most commonly used heat capacity because of the importance of enthalpy in most calculations.

(3) At constant volume $Q = dE$, and C_V results. C_V is always positive. However, C_V does not lend itself to simple experimental determination and it is generally calculated from a known C_P and Eq. (4).

(4) This equation (especially in its second form) is one of the most important since it shows us several things about heat capacity immediately:

- As the partial derivative $(\partial P/\partial V)_T$ is necessarily negative and $(\partial V/\partial T)_P^2$ must be positive, C_P is always greater than C_V. For ideal gases (see Table III), $C_P - C_V = R$; but for real gases $(C_P - C_V) > R$.
- Heat capacity at constant pressure approaches C_V as T approaches absolute zero; and at $T = 0$, $C_P = C_V = 0$.
- For the limiting case where

Exact Expressions for Heat Capacities—Table I

$$C = Q/dT = (dE/dT) + (P\,dV/J\,dT) \quad (1)$$

$$C_P = \left(\frac{\partial H}{\partial T}\right)_P = \frac{T}{J}\,\frac{(\partial V/\partial T)_P}{(\partial T/\partial P)_S} \quad (2)$$

$$C_V = \left(\frac{\partial E}{\partial T}\right)_V = -\frac{T\,(\partial P/\partial T)_V}{J\,(\partial T/\partial V)_S} \quad (3)$$

$$C_P - C_V = (T/J)\,(\partial P/\partial T)_V\,(\partial V/\partial T)_P \quad (4a)$$

$$= (-T/J)\,(\partial V/\partial T)_P^2\,(\partial P/\partial V)_T \quad (4b)$$

$$= (-T/J)\,(\partial P/\partial T)_V^2\,(\partial V/\partial P)_T \quad (4c)$$

$$= TV\beta^2/K_T J \quad (4d)$$

with $\beta = (1/V)\,(\partial V/\partial T)_P = (-1/\rho)\,(\partial \rho/\partial T)_P$ ($\beta = 0$ when $T = 0$)

and where $K_T = (-1/V)\,(\partial V/\partial P)_T = \dfrac{(C_P/C_V)\,g_c}{U_s^2\,\rho}$

$$(\partial C_P/\partial P)_T = -T\left(\frac{\partial^2 V}{\partial T^2}\right)_P \quad (5)$$

$$(\partial C_V/\partial V)_T = T\left(\frac{\partial^2 P}{\partial T^2}\right)_V \quad (6)$$

$$C_P/C_V = \frac{(\partial P/\partial V)_S}{(\partial P/\partial V)_T} = \frac{K_T}{K_S} \quad (7)$$

where $K_S = (-1/V)\,(\partial V/\partial P)_S = g_c/U_s^2\,\rho$

$$C_P = -\frac{(\partial H/\partial P)_T}{\mu} = \frac{T(\partial V/\partial T)_P - V}{\mu} \quad (8)$$

where $\mu = (\partial T/\partial P)_H$

Nomenclature (Consistent Units)

C	Heat capacity
d	Differential operator
E	Internal energy
g_c	Gravitational constant
H	Enthalpy
J	Mechanical equivalent of heat
K	Compressibility
L	Latent heat of vaporization
M	Molecular weight
P	Absolute pressure
Q	Heat quantity
R	Universal gas constant
S	Entropy
T	Absolute temperature
U_s	Velocity of sound

$(\partial V/\partial T)_P = 0$, $C_P - C_V$ also equals zero. This is the situation, for example, for water at 4 C. where density is a maximum and $\beta = 0$. Generally speaking, $C_P - C_V$ is small for solids and liquids since the external work of expansion is negligible; but for gases, the heat capacity is influenced considerably by the conditions of the heating process, so that $C_P - C_V$ may be quite large.

The last form, Eq. (4d), is derived from Eq. (4b) by introducing the coefficient of thermal expansion, β, and the isothermal compressibility, K_T, as defined in Table I. This form is particularly useful in some engineering calculations.

(5) and (6) These equations establish relations for the rate of change of C_P with pressure at constant temperature; and of C_V with volume at constant T. These two equations are the bases for some of the generalized charts to be discussed in a later section.

(7) This equation gives the heat capacity ratio, C_P/C_V, as the ratio of isothermal and adiabatic compressibilities, K_T and K_S, which are defined in Eqs. (4) and (7), respectively.

(8) This equation relates the Joule-Thomson coefficient, μ, with C_P through the derivative $(\partial H/\partial P)_T$. Sage and Lacey obtained C_P values from values of μ (over a temperature and pressure range) and the ideal gas heat capacities, C_P°, by means of a relation based on Eq. (8).

Sample Problem

Now, let's consider just one example of the many relations that we can get by combining the equations of Table I.

Heat Capacities of Saturated Fluids—Table II

Exact Thermodynamic

$$C_s = (Q/d\,T)_s \quad (1)$$

$$C_s - C_P = (-T/J)\,(\partial V/\partial T)_P\,(dP/dT)_s \quad (2)$$

$$= (-TV\beta/J)\,(dP/dT)_s \quad (2a)$$

$$C_s - C_V = (T/J)\,(\partial P/\partial T)_V\,(\partial V/\partial T)_P \quad (3)$$

$$C_{sV} - C_{sL} = (dL/dT) - (L/T) \quad (4)$$

Approximate Derived Expressions

$$C_{sL} - C_{PL} = (-V_{sL}/J)\,(dP/dT)_s \quad (1)$$

$$C_s - C_P = -V\beta L P M/J R T \quad (2)$$

$$C_{sV} - C_{PL} = (dL/dT) - (L/T) + (V_{sL}/J)\,(dP/dT)_s \quad (3)$$

$$C_{sL} - C_{PV} = (-dL/dT) - (V_sL/J)\,(dP/dT)_s \quad (4)$$

And, as a mean value between T_1 and T_2

$$C_{sL} = \frac{[(H_{T2})_{sV} - L_{T2}] - [(HT_1)_{sV} - L_{T1}]}{T_2 - T_1} \quad (5)$$

Heat Capacities for Ideal Gases—Table III

$$C_P - C_V = R \quad (1)$$

$$\gamma = C_P/C_V = C_P/(C_P - R) \quad (2)$$

$$C_P = R\gamma/(\gamma - 1) \quad (3)$$

$$C_V = R/(\gamma - 1) \quad (4)$$

$$(\partial C_V/\partial_V)_T = 0 \quad (5)$$

$$(\partial C_P/\partial P)_T = 0 \quad (6)$$

$$\mu = \left(\frac{\partial T}{\partial P}\right)_H = 0 \quad (7)$$

Notes—All heat capacities are on a molar basis. Eqs. (5) and (6) are functions of temperature only.

Suppose we know C_P for a liquid and need C_V and C_P/C_V at the same temperature (which would not often be the case). From Eq. (4d),

$$C_P = C_V + (T\beta^2/J\,\rho\,K_T)$$

where J, the mechanical equivalent of heat, has been introduced for dimensional consistency. Dividing by C_V,

$$C_P/C_V = 1 + \frac{T\beta^2}{J\,\rho\,K_T\,C_V}$$

Using a second definition of K_T from Eq. (4d), we get:

$$K_T = (C_P/C_V)\,(g_c/U_s^2\,\rho)$$

Combining these equations gives:

$$\gamma = C_P/C_V$$

$$\gamma = 1 + \frac{T\,U_s^2\,\beta^2}{g_c\,C_P\,J}$$

So that we can calculate:

$$(C_P/C_V)_L = \gamma_L$$

Both β and U_s can be calculated from density data:

$$\beta = \frac{\rho_1^2 - \rho_2^2}{2\,\rho_1\,\rho_2\,(T_2 - T_1)}$$

or,

$$\beta = \frac{\rho_1 - \rho_2}{\rho_{avg.}\,T_2\,(-T_1)}$$

where ρ_1 is the density at T_1; ρ_2 is the density at T_2; and T_1 and T_2 are chosen at equal intervals on each side of the temperature of interest.

$$U_s = (R\,\rho/M)^2$$

where the constant R, as described by Rao, can be obtained from the table in *Chem. Eng.*, Feb. 1957, p. 239.

Calculating γ_L, we can obtain C_V from:

$$C_{VL} = C_{PL}/\gamma_L$$

In Table I, above, Eq. (7) is obtained by substitution in the hydrodynamic equation for the velocity of sound in a fluid:

$$U_s = (dP/d\,\rho)^{0.5}$$

The vibration in such an experiment is adiabatic because of the rapidity of the pressure changes in the medium, so that no heat exchange occurs between the pressure and expansion regions of the wave. K_S is often determined experimentally in this manner. K_T is greater than K_S and is given by:

$$K_T - K_S = TV\beta^2/C_P$$

Ideal Gases Simplest

For the simplest case (ideal gases) $PV = RT$, and all of the

V	Volume
β	Coefficient of thermal expansion
γ	C_P/C_V
μ	Joule-Thomson coefficient
ρ	Density
∂	Partial derivative of

Subscripts

H	At const. enthalpy
L	For liquid phase
s	At const. saturation
P	At const. pressure
S	At const. entropy
T	At constant temperature
V	At constant volume; and for vapor phase

above relations can be simplified to those that are listed in Table III on the previous page.

For Saturated Fluids

Expressions for C_s, the heat capacity of a fluid at saturation, are given in Table II. Eq. (1) is the general thermodynamic definition for C_s, which is positive for liquids but may be positive, negative or equal to zero for vapors. For saturated steam, in fact, C_{sV} is negative for nearly all conditions.

The heat capacity, C_{sL}, for the case of a saturated liquid involves an enthalpy change from changes of both T and P:

$$dH_s = C_s\,dT + V_s\,dP$$

We can see that this is so if we consider a pure boiling liquid. If its temperature is increased, the pressure must also increase if saturation is to be maintained.

Under the exact thermodynamic heading of Table II, Eq. (2) is the fundamental thermodynamic relation for the difference in heat capacities of a fluid at constant saturation and at constant pressure. This equation may be applied to either phase. The derivative $(dp/dt)_s$ is merely the slope of the vapor pressure curve at the given condition. The derivative $(\partial V/\partial T)_P$ is quite small for liquids—excluding the region of the critical point—so that below a reduced temperature of about 0.85, $C_{PL} = C_{sL}$ with little error. K. M. Watson [*Ind. & Eng. Chem.*, Vol. 35, p. 398 (1943)] discusses the effect of higher reduced temperatures on $C_{PL} - C_{sL}$ for saturated water.

Introduction of the "compressibility-factor equation of state", $PV = ZRT$, into Eq. (2) gives the useful approximation for liquids which appears in the approximate expression part of Table II, where C_{PL} and C_{sL} are given in Btu./lb.-°F.; V_{sL} is specific volume in cu. ft./lb.; $(dp/dt)_s$ is in lb./sq. ft.-°F.; and $J = 778$ ft.-lb./Btu.

This relation depends on the law of corresponding states for generality and is approximately correct for liquids where V_{sL} is numerically small.

Eq. (4) is not so useful in the exact form—though it has been used for checking the consistency of thermodynamic data—but becomes more useful by assuming that $C_{sL} = C_{PL}$ and that approximate Eq. (1) holds. This gives approximate Eq. (3) as the working equation.

Approximate Eq. (2) comes from exact Eq. (2a) when we assume that the vapor is an ideal gas and the volume of the liquid is negligible compared to that of the vapor, and (dp/dt) is evaluated from the Clapeyron equation.

Eq. (4) under the approximate heading is obtained by combination of those preceding it.

For Liquids in General

In Table II, approximate Eq. (5) represents a general method for estimating the heat capacity of a pure liquid. The accompanying sketch below will give you a ready understanding of the various subscripts.

The procedure is as follows. The latent heats of vaporization are calculated at T_1 and T_2 (see later article for methods). If all calculated enthalpies are based on zero enthalpy for the liquid at T_1, L_{T1} becomes the enthalpy of the vapor at T_1 and under its own vapor pressure. This enthalpy is corrected to zero pressure by means of one of the several available relations for the effect of pressure on vapor enthalpy (see later section).

A zero-pressure heat capacity equation calculated from vibrational constants is used in integrated form to calculate the enthalpy of the vapor at T_2 and zero pressure. This value is corrected to the vapor pressure corresponding to T_2 to obtain the enthalpy of the saturated vapor at T_2. Deduction of the latent heat L_{T2} from this value gives the enthalpy of the saturated liquid at T_2.

By definition, the average specific heat of the saturated liquid for the temperature interval used is equal to:

$$(H_{T2})_{sL}/(T_2 - T_1)$$

since the enthalpy of the saturated liquid at the datum T_1 is zero. As discussed previously, $C_{PL} = C_{sL}$ for liquid except for $T_r > 0.85$. C_{PL} is representable as a linear function of temperature over only a limited range, so the temperature interval chosen should not be too large.

How Thermo Can Help

We've crammed a lot of thermodynamics into four printed pages. But don't expect thermodynamics to do everything. It can:

- Relate heat capacities for various conditions and phases.
- Give the effect of pressure on heat capacity.

It can not:

- Help with calculations at a point condition.
- Give the effect of temperature on heat capacity.

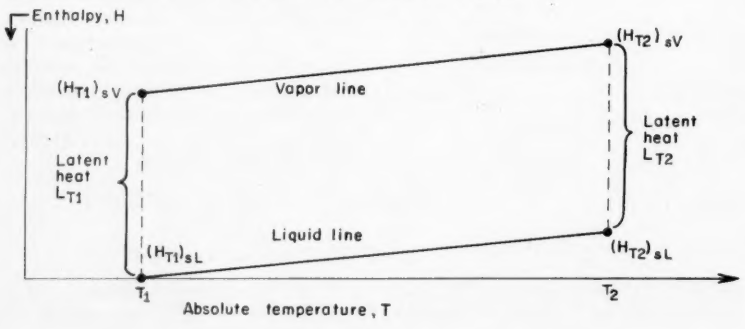
Next Month: Data Sources

In keeping with the general theme of this series, we do not plan to include extensive tables of experimental data for heat capacity.

However, we will list some selected references for such data in our discussion next month. Familiarization with these key compilations will lead the interested reader to the hundreds of individual studies upon which they are based.

We will also present a tabulation of empirical expressions that you can use to calculate the heat capacities of liquid and vapor petroleum fractions and pure hydrocarbons.

Use This Chart to Identify Subscripts



Topics and Organization of this CE Reference Series

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Your Design Reference File—III

Here is helpful reference information on pump selection, sealing, trouble shooting and costs; on ion exchange and exclusion; on electric motors and drives, to help you do a better design job.

RALPH CUSHING, Senior Process Engineer, Mobay Chemical Co., St. Louis, Mo.

Pumps and Pumping

General Selection

"Target: Standardized Pumps," *Chem. Eng.*, Feb. 1956, pp. 118, 120.
Who's working on standardization; where they're headed; present status.

"Seven Steps to Easy Choice of Pumps for Thick Liquids and Paper Stock," E. Schwandt, *Power*, Oct. 1955, pp. 124-127, 208.
Pump selection for fluids of heavy consistencies; effect of consistencies of fluid on head capacity factor.

"Pump Selection—A Method Based On Power Costs," Duke Silvestrive and Bruce Fader, *Chem. Processing*, June 1955, pp. 196, 198.
A nomograph for selecting pumps.

"Pumps," Tyler Hicks, *Power*, Oct. 1954, pp. 75-106.
Classes and types; pumping principles; speed and efficiency; impeller types; materials of construction; pump curves and system head curves; pump drives; rotary pumps; liquid end characteristics; reciprocating pumps; applications; stepwise pump selection procedure; operation and maintenance.

"Pumps," R. E. Dolman, *Chem. Eng.*, Mar. 1952, pp. 155-169.
Types; positive displacement; rotary pumps, characteristic curves; centrifugal pumps; impeller types; materials of construction; characteristic curves vs. speed and vs. impeller diameter.

Centrifugal Selection

"Evaluating Centrifugal Pumps," Donald Ullock, *Chem. Eng. Progress*, May 1955, pp. 207-222.
Factor in pump evaluation; effect of impeller design; pressures in the pump casing; supports; bearings; shaft deflection; critical speed; static and dynamic balancing of impellers; pressure on packing; shaft rubbing speed; temperatures; stuffing box design; mechanical seals; assembly.

"Design and Development of Seal-less Pumps," D. P. Litzenberg and H. T. White, *Chem. Eng. Progress*, Sept. 1954, pp. 436-444.
Service applications; design program; operating case histories; motor-stator; liner thickness vs. electrical losses, stator cooling methods; rotor design; bearings.

"Selection of Centrifugal Pumps," J. A. Cable, *Heating and Ventilating*, Dec. 1952, pp. 85-96.

Pump design basics; function of the parts; capacity; head; net positive suction head; speed; effect of temperature and specific gravity; drives; parts nomenclature; impeller types; types of fluids handled.

Rotary Pump Selection

"Rotary Pumps, Types and Applications," W. J. Mongon, *Plant Eng.*, Oct. 1954, pp. 90-91, 200.
Basic types of rotary pumps; aids to check proper application.

"Rotary Pumps—Selection, Care and Use," W. J. Mongon, *Plant Eng.*, Nov. 1954, pp. 124-127, 187, 189.
Operating conditions to be considered before selecting a rotary pump; suction lift; viscosity.

Metering Pump Selection

"Fundamentals of Controlled Volume Pumping," Robert Sheen, *Tech. Paper No. 65*, Milton Roy Co., Phila., Pa., 1955.
Describes use of controlled volume pumps as flow control instruments; typical systems described illustrating how pumps can be used as flow controllers, ratio controllers and final control elements.

Turbine Pump Selection

"Turbine Pumps Have Their Niche," A. B. Olmore, *Prod. Eng.*, Aug. 1953, pp. 173-177.
General characteristics; curves; theory of operation; efficiency; applications.

"The Modern Turbine Pump—Choice of Plant Operators for Specialized Jobs," E. L. Abramson, *Power*, Apr. 1955, pp. 120-123.
Head characteristics; lift; construction; capacity.

Vacuum Pump and Systems Selection

"Charts Solve Vacuum System Problems," R. Greenhalgh and J. W. Miller, *Chem. Eng.*, Jan. 1956, p. 222.
Nomographic solution for sizing vacuum pump and orifice; determining evacuation time for a system of any volume, from atmospheric pressure down to the desired vacuum.

"Your Rotary Vacuum Pump System," *Factory Management and Maintenance*, Aug. 1954, pp. 90-93.
How to install, operate and maintain; how it works; joints; valves; gaskets; trouble shooting.

"How to Pick a Vacuum System for Your Job," L. W. Hull, *Chem. Eng.*, Nov. 1953, pp. 200-202.
Charts and specified limiting conditions for selecting a vacuum pumping setup; costs; vacuum valves; pumping speed.

"Sizing and Selecting Vacuum Pumps," F. J. Stokes Machine Company, *Chem. Processing*, July 1953, p. 50.
Graphical solution, pump down factor vs. absolute pressure; example calculations.

"Vacuum Systems for Industrial Apparatus," N. Maleady, *Prod. Eng.*, Feb. 1951, pp. 121-123.
Conductance of pipes; pump sizing; pump capacity.

"How to Figure Reciprocating Vacuum Pumps," T. G. Hicks, *Chem. Eng.*, June 1950, pp. 108-110.
Evacuation time calculations; low vacuum applications; characteristic curves; horsepower curves; power requirements.

Pump Sealing

"Mechanical Seals," Steve Elonka, *Power*, Mar. 1956, pp. 109-132.
Packing type seal compared with mechanical seal; stationary vs. rotating mechanical seals; balanced and unbalanced types; surfaces; face combinations and liquids they seal; available mechanical seals; custom built seals; high pressure and high temperature seals; corrosion; abrasive liquids; cooling seals.

"How to Select and Install Pump Seals," T. J. Sniffen, *Pet. Refiner*, Mar. 1954, pp. 207-210.
Basic principles essential to successful application of mechanical seals; seal elements; operation; static point sealing; seal selection; installation precautions; seal materials.

"Know Your Mechanical Seals," J. S. Swearingen, *Chem. Eng.*, Nov. 1955, pp. 213-216.
Coolant lubricant; operation of seal; run-out and misalignment; balancing pressure; commercial types.

"Thirteen Ways to Solve Packing Problems," R. Norton, *Chem. Eng.*, Mar. 1955, pp. 183-186.
How to prevent shaft and packing wear on centrifugal pumps for abrasive liquids; shaft deflection.

"Here's Latest on Mechanical Packing," S. Elonka, *Power*, Mar. 1955, pp. 107-130.
Packing types; box and packing design; shaft gyration; abrasion; high temperature; chrome plating; automatic packings and semiautomatic packings; O-ring seals; lantern rings and lubricating systems; cooling the packing set; expansion joint packings; ball and swivel joints; special types and applications; installation; how packing types resist gases and fluids that you seal.

"Mechanical Seals for Centrifugal Pumps," Igor Karassik and Ray Carter, *Heating and Ventilating*, Dec. 1954, pp. 92-94.
Basic mechanical seal arrangement; design; applications.

"Stuffing Box and Packing for Centrifugal Pumps," Igor Karassik and Ray Carter, *Heating and Ventilating*, Nov. 1954, pp. 85-88.
Seal cages; throat bushings; design; application; stuffing box packing; water cooled stuffing boxes; pressure reducing devices; stuffing box glands.

"Oil Seals—Their Function, Selection and Operation," E. Stohl, *Plant Eng.*, May 1953, pp. 92-96, 168, 170.
Non-pressure seals and closures for rotating shafts; types of seals; design; arrangement; applications.

"Using Mechanical Seals for Centrifugal Process Pumps," D. Rankin, *Heating, Piping and Air Cond.*, Oct. 1951, pp. 102-105.
Application of pump seals; designing pumps for use with mechanical seals; differences between various seal types; balanced seal; double seals.

Costs and Savings

"When to Replace a Pump," C. Cromwell, *Pet. Refiner*, Sept. 1954, pp. 300-302.
How to determine hidden costs and compare with replacement costs; nomograph with examples.

"Calculating Savings When New Pump Replaces Old One," C. E. Cromwell, *Heating, Piping and Air Cond.*, June 1954, pp. 133-134.
Nomographic chart with examples; annual savings.

Maintenance and Trouble Shooting

"How to Control Centrifugal Pump Noise," L. M. Evans, *Power and Fluids*, Spring 1956, pp. 13-17.
Impeller vanes; speed; coupling misalignment; axial play; cavitation; unbalanced rotors; pipe strain; field test for noise; noise control; piping supports; isolation mounts; scale of sound levels for typical noises; air-borne noise.

"Regular Maintenance for Canned Pump Pays Off," A. Fell, Jr., *Power*, Apr. 1956, pp. 120-121, 200.
Step by step maintenance procedure, pictorial with text.

"How to Trouble Shoot Centrifugal Pumps," *Factory Management and Maintenance*, June 1955, p. 154.
Tabular arrangement; trouble, cause and remedy.

"Installation and Maintenance of Controlled Volume Pumps," *Tech. Paper No. 63*, Milton Roy Co., Phila., Pa., 1954.
Installation; suction and discharge piping; preventive maintenance; packing; checking; trouble shooting chart; spare parts.

"Cut Impeller Erosion—Easily," T. W. Edwards, *Chem. Eng.*, Dec. 1953, pp. 170-171.
Low capacity operation; internal recirculation; abrasive fluids; bypass arrangements; how bypass arrangements affect system head curves; graphical presentation given.

"Centrifugal Pumps (Operation and Maintenance)," *Plant Eng.*, Apr. 1952, pp. 95-98.
Location; physical features of suction and discharge piping; priming; startup; maintenance procedures; erosion.

"Instructions for Operating Centrifugal Pumps," *Heating, Piping and Air Cond.*, Dec. 1948, pp. 103, 104.
Priming; startup; maintenance; trouble shooting.

General Pumping Calculations

"How to Calculate Temperature Rise in Centrifugal Pumps on Closed Discharge," L. Karassik and T. Edwards, *Industry and Power*, June 1955, pp. 54-58.
Formula for calculating temperature rise; equilibrium temperature; time vs. temperature; radiation; empirical formulas; pneumatic and electric recirculation control systems.

"Cut Pump Specification Work with Standard Data Sheet," S. R. Cox, *Chem. Eng.*, Apr. 1955, pp. 170-171.
Determining head conditions; tabular, concise arrangement of a calculation form and data sheet.

"How to Solve Pumping Problems," G. D. Roper Corp., *Form* 3060, Apr. 1954.
General explanation of rotary gear pumps; sample problems; friction loss in hose and pipe; viscosity effects; conversion tables; materials of construction; friction drop charts contain direct reading parameters for viscosities up to 10,000 ssu.

"Sizing Pumps," Robert Hlavin, *Chem. Eng.*, Sept. 1953, p. 57.
Nomographic solution for brake horsepower from pressure drop, capacity and pump efficiency.

"It's Easy to Determine NPSH," Dan R. Rankin, *Pet. Refiner*, June 1953, pp. 129-132.
Characteristic curves; formulas for NPSH for various types of installations; examples and illustrations.

"What is NPSH?," Dan R. Rankin, *Pet. Refiner*, May 1953, pp. 162-165.
Introductory explanation of NPSH; pumping at sea level; pumping liquids with high vapor pressure from open tanks; effect of altitude; liquids at boiling points.

"How to Use System Head Curves," M. Mann, *Chem. Eng.*, Feb. 1953, pp. 162-164.
Presentation of how to use characteristic curves and system head curves to analyze a number of different operating conditions—a graphical method.

"Establishing Safe Minimum Flow for Centrifugal Pumps," E. C. Condict, *Chem. Processing*, Nov. 1952, pp. 190, 192.
Allowable temperature rise; graphical method.

"How to Choose the Right Impeller," J. A. Cable, *Chem. Eng.*, Nov. 1952, pp. 144-145.
Types; physical dimensions; scale formation; suspended solids.

"Don't Oversize Pumps," H. Lockhart and L. Oosten, *Heating, Piping and Air Cond.*, Aug. 1952, pp. 102-104, 111.
Temperature drop in a heating system; friction losses in the system; selection; pump capacity chart; flow and friction.

"Pumping Viscous Materials," Wm. E. Worcester, *Pet. Refiner*, Feb. 1950, Kinney Mfg. Co. reprint.
Gear pumps and rotary pumps; pressure loss in viscous material pumping; viscosity conversion table; effect of entrained gas on rotary pump displacement; effect of viscosity on pump speed.

Centrifugal Calculations and Applications

"Centrifugal Pump Application—Parts I-V," Igor J. Karassik and Roy Carter, *Air Cond., Heating and Ventilating*, Feb.-June 1956.
Part I—Feb. 1956; pp. 77-81.
Head terms; general application and selection criteria.
Part II—Mar. 1956, pp. 115-117.
Pump heads; suction conditions; head and lift; NPSH, specifying suction conditions.
Part III—Apr. 1956, pp. 78-80.
Pump heads; discharge conditions; typical discharge systems; specifying discharge head; total head; head terms for vertical pumps.
Part IV—May 1956, pp. 77-80.
Characteristic curves and pump relations; analysis of characteristics including capacity; head; efficiency and horse power; mathematical relations.
Part V—June 1956, pp. 79-80.
Rating curves and specific speed; effects of pump shapes and speed on rating curves, suction lift, and net positive suction.

"Rate Your Centrifugal Pumps," N. Sag, *Chem. Eng.*, July 1955, pp. 223-226.
Calculations when centrifugal pumps feed a common pipeline can be complicated; a simple, graphical method given to find the actual working point of each pump under any set of conditions; step by step example calculations.

"Centrifugal Pump Materials," Igor J. Karassik and Roy Carter, *Air Cond., Heating and Ventilating*, June 1955, pp. 120-123.
Pump casings, impellers, wearing rings and shafts; fittings; effect of load and structural features; galvanic corrosion.

"Vertical Wet Pit Centrifugal Pumps," Igor J. Karassik and Roy Carter, *Air Cond., Heating and Ventilating*, Apr. 1955, pp. 116-119.
Vertical turbine pumps; vertical propeller pumps; wet pit sewage pumps; sump pumps.

"Vertical Dry Pit Centrifugal Pumps," Igor J. Karassik and Roy Carter, *Air Cond., Heating and Ventilating*, Mar. 1955, pp. 103-106.
Types and operation described; drivers; shafts; bearing; structural design.

"Centrifugal Pump Couplings," Igor J. Karassik and Roy Carter, *Air Cond., Heating and Ventilating*, Feb. 1955, pp. 109-112.
Rigid couplings; flexible couplings; floating shaft couplings; clutch type couplings; couplings for dual drives; magnetic clutches and drives for centrifugal pumps.

"Centrifugal Pump Bearings," Igor J. Karassik and Roy Carter, *Air Cond., Heating and Ventilating*, Jan. 1955, pp. 97-100.
Mechanical arrangements and lubricating methods;

ball bearings; sleeve bearings; mechanical features of bearing construction.

"Centrifugal Pump Shafts and Shaft Sleeves," Igor J. Karassik and Roy Carter, *Air Cond., Heating and Ventilating*, Oct. 1954, pp. 95-98.
Critical speeds, shaft deflection and design; shaft sleeve.

"Axial Thrust In Centrifugal Pumps," Igor J. Karassik and Roy Carter, *Heating and Ventilating*, Sept. 1954, pp. 103-105.
How axial thrust, the sum of unbalanced forces acting on a centrifugal pump impeller, works in pumps.

"Centrifugal Pumps—Impellers and Wearing Rings," Igor J. Karassik and Roy Carter, *Heating and Ventilating*, Aug. 1954, pp. 91-94.
Analysis of the forms and functions of impellers, and the structure of wearing rings.

"Centrifugal Pump Casings," Igor J. Karassik and Roy Carter, *Heating and Ventilating*, July 1954, pp. 77-80.
Shapes, applications and terminology of pump casings.

"Centrifugal Pumps, Types and Trends," Igor J. Karassik and Roy Carter, *Heating and Ventilating*, June 1954, pp. 73-76.
Types available; effect of speed; size; causes of noise.

"The Application of Centrifugal Pumps," A. E. Hainsbeiger, *Pet. Refiner*, Jan. 1951, pp. 119-128.
A presentation of the factors affecting selection, procurement, operation, and maintenance of various types of pumping equipment; capacity; total head; suction conditions; speed; horsepower; specific gravity, temperature, viscosity of fluid; corrosion; abrasion; stuffing box.

Water Treatment and Supply

General Considerations

"Water—What It Contains," Eskel Nordell, *Chem. Eng.*, Sept. 1955, pp. 183-188.
Soluble mineral impurities; other impurities; typical rivers, lakes and surface waters listed giving turbidity, hardness and color; dissolved gases; water uses; process water specification; losses of alkaline materials by reaction with hard water; cooling tower water; boiler feed water; water conditioning processes used in typical process industries tabulated.

"Water—How It's Treated," Eskel Nordell, *Chem. Eng.*, Oct. 1955, pp. 175-184.
Sodium cation exchange; hydrogen cation exchange; ion exchange demineralization; cold lime-soda process; hot lime-soda process; coagulation, settling, filtration; aeration; deaeration; iron and manganese removal; data for water treatment calculations; chemical requirements for water treatment; treating costs.

"Industrial Water Treatment," Eskel Nordell, *Industry and Power*, June 1955, pp. 40-43.
Water clarification; filters and filter media; hardness scale; types of conditioning equipment; hot lime soda softener; base exchange principle; increase in temperature differential caused by boiler scale with different conduction constants; solubilities of common salts that cause hardness; hydrogen cation exchange.

"Water," *Power*, Sept. 1952, pp. 73-117.
Sources of supply; river control; navigation; water shortages; water usage; irrigation; industrial use of water; pollution control; water treatment processes; integrated water use programs; water surveys; waste disposal; procedure for evaluation of water supply in plant site surveys; floods; wells; ocean sites. Good general covering of the subject with interesting style. Well illustrated.

"If You Use Water," Rohm & Haas Co.,*IE-1*, May 1954.
Discussions of the various water treatment methods, giving equations and simplified flowsheets of the processes; quality of water obtained from various sources. Fluoride removal; special applications.

Boiler Feed Water

"New Way to Remove Feedwater Silica," S. B. Applebaum and B. W. Dickerson, *Power*, Apr. 1955, pp. 83-85.
Salt splitting; demineralizing; chloride anion exchange; hydroxyl anion exchange; test results; operating costs; equipment costs; sodium zeolite; hydrogen sodium zeolite.

"Stop Scale Formation in Your Boiler With Proper Treatment," L. W. Fitzpatrick, *Power*, Feb. 1955, pp. 106-108.
Scale and sludge; solidity of common chemical compounds; internal chemical treatment; phosphate selection; scale-control tests.

"Scale Formation in Steam-Water Cycles: Its Location, Cause and Cure," H. E. Eigner, *Power*, Dec. 1954, pp. 118-120.
Tabular form giving name and formula, location of scale; cause of formation and treatment required.

"Hydrazine: New Aid To Water Treatment," Eric R. Woodward, *Power*, Nov. 1953, pp. 91-93; 212-217.
Foreign test results; reaction of oxygen with hydrazine; corrosion; chemical and handling problems; treatment costs; degassing; hydrazine chemical tests; potentiometric titration.

"Controlling Scale Formation in Water Treatment," M. R. Beychok, *Chem. Eng.*, July 1952, pp. 160, 162.
Based on laboratory test methods, a nomograph is given to predict the formation of scale in the system. Carbonate and sulfate scale.

"Conditioning Water For High Pressure Boiler Service," R. T. Hanlon and W. H. Thompson, *Southern Power and Industry*, July 1946, National Aluminate Corp. reprint #13.
Selection of treatment system; pretreatment system; contamination of condensate; oxygen removal; treatment of boiler water; sludge conditioning in the boiler; steam conditioning.

"Use of High Alkalinity and Organic Materials For Sludge Removal In High Pressure Boilers," Selden K. Adkins, *Proc. of the Midwest Power Conference*, Apr. 1948, National Aluminate Corp. reprint #12.
Case history South Omaha Steam Electric Station; results, conclusions, recommendations.

Cooling Tower Water

"Test Cooling Water for Corrosion by These Methods," M. C. Forbes, *Pet. Refiner*, Apr. 1953, pp. 130-133.
A simple and economical evaluation procedure. Parallel nipple test; series nipple test; National District Heating Assn. tester; test coupons; washers; test interpretation; effect of time on corrosion rate.

"Water Treatment for Cooling Towers," John B. Davis, *Heating, Piping and Air Cond.*, Apr. 1950, pp. 89-93.
Types of cooling systems; cooling system problems; weight and volume comparisons of constituents in a condenser; characteristics of deposits; equilibrium conditions for calcium carbonate at various pH values; water softening by lime treatment; control of corrosion; scale prevention; zeolite treatment; sulphuric acid treatment; surface active agents; chlorination; control procedures and operating range; data needed for water treatment selection.

Demineralization

"Automatic Control for Mixed Bed Demineralizer," J. S. Samkoff, *Industry and Power*, Nov. 1955, pp. 39-42.
Demineralizer bed components; flow and level control; pH control; flow diagram of water treating system; alarm system; valve position indicator.

"Water Without Minerals," I. B. Dick, *Instrumentation*, Third Quarter, 1955, Minneapolis-Honeywell Regulator Co.
Automatically controlled demineralizers; instrumentation; central control; regeneration cycle.

"What's New in Demineralizing," Durando Miller, *Power*, July 1955, pp. 73-77.
Equipment arrangements; alternating series; polishing demineralizers; mixed bed polishing; countercurrent regeneration; control; gravity mixed bed units; recirculation; conductivity vs. dissolved solids.

"Demineralization—A Means to Purer Water," James Boyd Smith, *Industry and Power*, Oct. 1954, pp. 57-72.
Principles of operation; impurities present in water supplies; types of process; degasification; system arrangements; modified system; head loss through resin bed at various flow rates and temperatures; equipment design; flow distribution; pressure loss; expansion of bed at backwash rates and temperatures; regeneration; piping and valves; types of exchangers; conductivity vs. solids content; regenerant costs; economics; instrumentation; automatic operation.

"Two New Slants On Deionization: Keeping Up Water Quality and Lowering Operating Costs," F. X. McGarvey and A. C. Reents, *Power*, July 1954, pp. 75-78.
Trouble shooting; the problem of large organic ions; highly porous resins; resin cleanup, chemical pretreatment.

"Economic and Operating Aspects of Mixed Bed Deionizers With Hard and Soft Water Supplies," J. F. McGill, *Power*, July 1954, pp. 79-81.
Influents; hard water; regeneration techniques; investment; labor costs; practical aspects; economic advantages of soft water supply.

"Demineralization Passes in Review," S. B. Applebaum, *Power*, Aug. 1953, pp. 88-91; 196, 198, 202.
A summary and comparison of materials and processes in the demineralization field. Chemistry; cation materials; resins; regeneration; reaction problems; anion exchange design; treatment methods; equipment costs; mechanical aids; regeneration; instrumentation; mixed bed demineralizers.

"Mixed-Bed vs. 2-Step Demineralizing," M. E. Gilwood and D. C. Calmon, *Power*, May 1953, pp. 73-76.
Comparison between two types based on capacity; economics; process efficiency; regeneration.

"Demineralization Including Silica Removal," The Permutit Co., *3803*, Sept. 1955.
Principles; regeneration; equipment arrangements.

Water Softening

"Water Softening Methods—Each Has Its Advantages and Its Limitations," *Plant Eng.*, Aug. 1955, pp. 106-108.
Sodium ion exchange; lime soda process; comparison based on efficiency and costs.

"Economics of Softening Cooling Water," Maxey Brooke, *Pet. Refiner*, Oct. 1954, pp. 145-146.
Complete treatment of cooling water treatment economics; capital investment and maintenance costs.

Ion Exchange

"Ion Exchange in the Fine Chemicals Industry," James Gillin, *Chem. Eng. Progress*, Dec. 1955, pp. 547-550.
Protein desalting; neutralization; ion interchange; adsorption elution; process development; contact time vs. adsorptive capacity.

"Ion Exchange," Neven K. Heister and Russell C. Phillips, *Chem. Eng.*, Oct. 1954, pp. 161-180.
Operating and investment costs; exchange materials; types of exchangers; capacity; list of manufacturers; batch exchangers; equipment; design; fixed bed ion exchange; efficiency curves; applications; comparative costs evaporation vs. demineralization; metal recovery; organic purification; ion exclusion; continuous processes; applications, costs; ion separation; electromembrane ion exchange.

"Get Rid of Fouling in Ion Exchangers," F. X. McGarvey and A. C. Reents, *Chem. Eng.*, Sept. 1954, pp. 205-208.
Trouble shooting; loss of water quality; how large ions affect exchange; effect of diffusion; cleanup; pretreatment by chlorination; oxidant effect on effluent resistivity.

"Ion Exchange," Robert Kunin and F. McGarvey, *Ind. and Eng. Chem.*, Jan. 1954, pp. 118-125.
Bibliographies and reviews; theory; membranes; water softening; biochemical separation; recovery; waste treatment; catalysis; ion exchange resin synthesis; medical applications.

"Principles of Ion Exchange Processes," The Dow Chemical Co., *Pub. No. 1*, 1954.
Fundamental principles; functional groups; resin selectivity; techniques; rate of exchange; efficiencies; application in water conditioning, purification, concentration; ion exclusion; non-ionic separations.

"Dowex Five Mesh Resins," The Dow Chemical Co., *Pub. No. 2*, 1954.
General description of styrene divinyl benzene copolymers; moisture content; capacity; summary of crosslinkage effects; particle size; equilibration rate; flow rate; pressure drop; summary of particle size effect.

"Industrial Ion Snatchers . . . Cation and Anion Exchangers," Eskell Nordell, Permutit Co., *3878*, May 1953.
General approach; background of zeolite exchange processes; capacity ratings of sodium cation exchangers; carbonation and resin type cation exchangers; anion exchanger resins; demineralization.

"Metal Recovery by Ion Exchange," C. F. Paulson, The Permutit Co., *3737*, Nov. 1952.
Theory of ion exchange; metal recovery from anionic or cationic complex by cation exchange; metal removal from acids by anion exchange; precious metals; recovery of electroplating wastes; some cost comparisions; capacities; typical flow sheets.

"Quality Of Water Produced by Ion Exchange," A. C. Reents and J. F. Wantz, Illinois Water Treatment Co. booklet, Mar. 7, 1952.
General presentation; tabular arrangement of a comparative water analysis before and after treatment with weak base, strong base, and mixed bed systems; graphical presentation, % of cycle vs. pH and conductivity of solution.

"Ion Exchange Develops as a Unit Process," James C. Winters, *Chem. Ind.*, May 1948, pp. 754-758.
Description of ion exchange as applied to several chemical processes. Beet sugar purification; biochemicals; catalytic activities; theory of ion exchange; plant nutrients; cation and anion exchange; rare earth separation; waste recovery.

Ion Exclusion

"Concentration Effect of Recycling in Ion Exclusion," D. W. Simpson and W. C. Bauman, *Ind. and Eng. Chem.*, Sept. 1954, pp. 1958-1962.

Concentration effects of recycling in ion exclusion; system selection; development of equilibrium operating cycle; initial concentrations.

Waste Treatment

"Solution of Some Industrial Water and Waste Treatment Problems," J. Procopi and G. E. Shaffer, Jr., *Industrial Wastes*, Nov.-Dec. 1955.
Flow diagrams; process water treatment; coagulation; clarification; boiler water treatment; removal of dissolved oxygen; waste treatment.

"Safe Disposal Methods for Liquid Industrial Wastes," Edmund B. Besselievre, *Air Cond., Heating and Ventilating*, Apr. 1955, pp. 100-110.
Legal right to streams; definition of pollution; approach to the pollution problem; design of waste treatment systems; types of treatment; operational charges; gas production; economics; biological methods; chemical treatment; synthetic resin units; activated sludge; automatic control; agitation; flocculation; sedimentation; filters; digestion tanks; dewatering sludge.

"A 1955 Survey; Waste Treatment Methods," H. L. Jacobs, *Chem. Eng.*, Apr. 1955, pp. 184-188.
Disposal problems; concentrating wastes; adsorption; incineration; chemical treatment; biological treatment; activated sludge; catalytic treatment; ion exchangers; tree farming; process improvements to keep waste to a minimum.

"New Process Whips Waste Disposal Problems," Haviland F. Reves, *Pet. Refiner*, Oct. 1953, pp. 139-140.
Circular separators; biological oxidation; flue gas distillation; preventive measures; trickling filter operation.

"The Water Pollution Problem—Get Ready to Tackle It!," Melvin Nord, *Pet. Refiner*, Oct. 1952, pp. 125-130.
Legal definition of pollution; contaminants, effects and tolerances; polluting criterion; stream turbulence; oxygen balance; systematic analysis; the legal aspects of stream pollution are discussed in some detail.

"Fundamentals and Performance of Gravity Separation," Alfred C. Ingersoll, *Pet. Refiner*, June 1951, pp. 106-118.
Thorough review of available information on the settling velocity of particles, the settling of suspensions; sedimentation in fill and draw basins and under continuous flow, sediment transportation; design criteria for settling tanks; use of traces and models; separation of particles lighter than water.

"Solved—Difficult Waste Disposal Problem," Kenneth M. Brown and Soma Kurtis, *Pet. Refiner*, Aug. 1950, pp. 111-115.
Description of a practical industrial process using carbon dioxide for neutralizing caustic wastes. Difficulties encountered in the operation of the method are noted and the solutions discussed. Facts, figures and flow sheets given.

Water Analysis

"Water Problems and Their Solutions, Parts I-III," M. C. Forbes, *Pet. Refiner*, Apr.-July 1954.
Part I—Apr. 1954, pp. 122-126.
Part II—June 1954, pp. 169-171.
The following analyses are discussed: carbon dioxide, hydrogen sulfide, ammonia, dissolved oxygen, chlorine, alkalinity, acidity, chlorides.
Part III—July 1954, pp. 131-133.
Other analyses are discussed; sulfate, sulfite, phosphates, chromates, nitrates, nitrites, silica, iron, manganese, total hardness, sodium, pH, specific conductivity, comparative analyses and material balances.

Electrical Equipment and Problems

Motors

"Selecting Motors for Fans and Centrifugal Pumps," C. G. Veinott, *Prod. Eng.*, May 1956, pp. 217-219.
Nomograph based on torque, power, speed.

"Starting Methods for Three-phase Motors," H. W. Cory and T. F. Ballinger, *Prod. Eng.*, Feb. 1956, pp. 183-198.
Advantages and limitations of selective starting; low voltage protection; time delay under voltage and low voltage release with automatic starting; reduced-voltage starting by autotransformer; reactor or resistor control; wound-rotor motors and controllers for high starting torque, smooth acceleration and limited starting torque.

"Pointers on the Selection of Fractional Horsepower Motors," T. E. M. Carville and L. W. Buchman, *Air Cond., Heating and Ventilating*, Jan. 1956, pp. 57-64.
Each type motor is described; an application table plus data clarify the kind of service for which each class motor is best suited; motor protection.

"When to Specify Special Motors," Robert G. Dobbin, Jack and Heintz Inc., *Form No. 2.2*, Nov. 1955.
Allowable motor temperature rise; motor service factors; world power supplies; details and specifications of dc. and ac.-dc. fractional and sub-fractional horsepower motors; motor shape; how modifications can be specified.

"Today's Electric Motors—Major Key to Modern Industrial Growth," James J. O'Connor, *Power*, June 1955, pp. 73-104.
Enclosures; bearings and lubrication; auxiliaries, special designs; insulation; motor types; motor performance; electrical supply; operating conditions; starting methods; commutator motors; synchronous motors; capacity type; dc. motors; adjustable speed; performance; torques.

"Choose Motor Enclosure to Fit the Weather," M. R. Lory and J. F. Heidbreder, *Power Eng.*, Jan. 1955, pp. 74-75, 96, 98.
Enclosure types; applications; costs.

"How to 'Spare' Large Motors and Controls," R. L. Gehring, *Plant Eng.*, Dec. 1954, pp. 92-93.
Planning replacements; storage of spare parts; recommended replacement parts for different types of motors.

"Temperature Rise in Motors and What It Means," Tom M. Gayle, *Plant Eng.*, June 1954, pp. 84-85, 162, 164.
Difference in "observed" temperature and actual temperature; permissible operating temperature; effect of excess temperatures; controllable factors affecting heating.

"New Nema Standard Motors—How Interchangeable?," *Plant Eng.*, Apr. 1954, pp. 98-101, 174, 176, 178.
Guide posts and warning signals regarding what can be expected in representative interchanges of motors of old and new frame sizes.

"Once Over Lightly—Selection Guide for AC Motors," Tom M. Gayle, *Plant Eng.*, Nov. 1953, pp. 89-92, 194.
A practical, quick guide to application of motors based on a lumping of basic design types; power requirements; mechanical design.

"New Motors to Have More Power," *Chem. Eng.*, Oct. 1953, pp. 250-252.
Comparison of old and new Nema standards; preferred standard dimensions.

"Industrial Electric Motors," W. T. Watt, *The Plant*, Mar., April 1953 (reprint No. 57) Elliott Co.

Operating characteristics and application data; speed; characteristics; starting currents; temperature rise; power factor; adjustable speed; power factor; starting methods; controls; high voltages.

"Starters for Industrial Type AC Motors," G. W. Heumann, *Heating and Ventilating*, (reference section), Apr. 1953, pp. 111-126.
Squirrel cage motors; wound rotor motors; torque-speed curves; load characteristics; full voltage starting; manual starters; hermetically sealed motors; magnetic starters; pilot devices; reduced voltage starters; short circuit protection; combination starters.

"Electrical Machinery—Tips on Selecting Motors," J. J. O'Connor, *Power*, July 1951, pp. 108-112.
Types of enclosures; insulation temperature; variable load cycles; types of motors; motor characteristics; applications converters and rectifiers.

"Motors and Motor Control," Victor J. Kropf, *Chem. Eng.*, July 1951, pp. 123-136.
Factors in selection; applications; motor ratings; relative costs; motors for constant speed drives; variable speed drives; control equipment; mechanical features; ventilation; bearings.

"Choice of DC Motors," Joseph Winston, *Prod. Eng.*, July 1951, pp. 125-130.
The use of dc. motors in ac. locations; characteristics; tapered horsepower; compound and series motors; brake and gear motors; costs.

"Selection of Induction Motors for Air Conditioning, Heating and Ventilating Equipment," George Nafe, *Heating and Ventilating*, June 1951, pp. 75-84.
Installation; torque requirements; electrical characteristics; mechanical construction; starting current; torque; induction motors; single phase motors; low voltage; polyphase motors; protective devices; starters; motor enclosures; insulation; operating temperatures.

Drives

"Proper Control Is Important When You Use Constant-Speed Motors," G. W. Heumann, *Industry and Power*, Nov. 1955, pp. 35-38.
Full voltage starters; reversing starters; autotransformer starters; primary impedance starters; increment starters; part winding starters; synchronous motor starters; wound rotor motor starters.

"Adjustable Speed Drives and Electrical Controls," A. B. White, *Industry and Power*, Sept. 1952, pp. 69-98.
Application factors; load characteristics; drive characteristics; types; automatic control methods; amplifiers and servomechanisms; location; selection; mechanical transmissions; eddy current drives; dc. converters; adjustable speed drives.

Circuit and Motor Protection

"Fault Currents: Today's Big Problem," *Power*, Mar. 1956, pp. 80-81.
Trimming short circuit current values; current limiting fuse; busways; interrupting capacity.

"Power Relays and Circuit Breakers," Charles T. Fish, *Pet. Refiner*, Jan. 1956, pp. 144-146.
Preventive maintenance procedure; maintenance schedule and report forms.

"Large Motors Need Special Protection," Sackville B. Hoag, *Chem. Eng.*, May 1955, pp. 187-191.
Protecting against mechanical and electrical hazards; moisture; corrosion; explosive abrasive and conductive materials; recommendations for protection of large motors used in chemical plants; control; location; enclosures.

"Which Circuit Breaker Is Easier to Maintain: Oil-filled or Oilless?," W. B. Wilson and James Ervin, *Power Eng.*, Mar. 1955, pp. 52-53.
Text with illustration showing maintenance procedures for both types.

"Which Circuit Breaker for Industry—Oil or Oilless?," W. B. Wilson and James Erwin, *Power Eng.*, Feb. 1955, pp. 80-82.
Two types are explained and compared.

Transformers

"Weigh These Facts When You Buy a Transformer," L. W. Schoeing, *Factory Management and Maintenance*, Oct. 1955, pp. 110-113.
Cost comparisons; power losses in service; efficiency; phases; coolant; load factor.

Electrical Heating

"Electric Heating Elements," Cutler-Hammer Co., *EC-53a*, Jan. 1956.
Selection and application data.

Maintenance

"Maintenance of Industrial Electrical Equipment," E. B. Curdts, James G. Biddle Co., *Bulletin 21P9*, June 1955.
Preventive maintenance techniques, procedures, costs.

"Maintaining Transformers," P. Belsky, *Factory Management and Maintenance*, Sept. 1954, pp. 134-136.
Ventilated dry type transformers; liquid filled transformers; preventive maintenance procedure.

"Maintaining Switchgear," P. Belsky, *Factory Management and Maintenance*, Aug. 1954, pp. 142-144.
Low-voltage, drawout switchgear; regular maintenance schedule; oil breaker metal-clad switchgear; air breaker metal-clad switchgear; inspection; parts replacements; tests.

"Bearing Maintenance for Industrial Electric Motors," J. W. Samzelius, *Plant Eng.*, Jan. 1954, pp. 108-110, 172.
Ball bearings with grease lubrication; alignment; endplay; trouble shooting.

"Bearing Maintenance for Industrial Electric Motor," J. W. Samzelius, *Plant Eng.*, Dec. 1953, pp. 84-86.
Step by step procedure for rebabbitting; pressing in; sealing and operating sleeve bearing.

"Motor Maintenance," W. R. Harris and W. W. McCullough, James G. Biddle Co., *Bulletin 21P-16*, Nov. 1953.
A survey of causes of motor failure; definite instructions on steps to be followed to avoid failures; preventive maintenance procedures; maintenance check chart for ac. and dc. motors; insulation.

Calculations

"How Much Horsepower Delivered," F. W. Michal, *Factory Management and Maintenance*, May 1956, p. 152.
Nomograph solution for horsepower.

"Constants Make Electrical Calculations Easier," Wm. O'Brien, *Power*, Nov. 1955, p. 103.
Tabular form presents constants for electrical calculations for various voltages, ac. and dc. systems.

"Watt Loss in Electrical Conductors," Norton Savage, *Power*, Aug. 1955, p. 101.
Graphical presentation; length of run vs. watts loss for various current flows.

CE Flow File—V

A new group of seven formulas on flow of liquids continues the series. Here are the first four.

Maxey Brooke, Chemical Engineer, Old Ocean, Tex.

(For author biography see *Chem. Eng.* Jan. 1957, p. 298.)

16. Liquids

APPLICATION

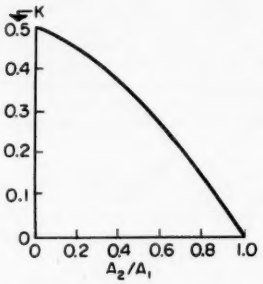
Pressure drop due to sudden contraction of pipe cross section

FORMULA

$$P = 0.00112KSV^2 (1/D^4)$$

NOMENCLATURE

P = Pressure drop, lb./sq.in.
S = Specific gravity (water = 1.0)
V = Flow, gpm.
D = Diameter of downstream section, in.
K = Constant from chart
A_1 = Area of flowing section
A_2 = Area of contracted section



REFERENCE

Schutt, **Hydraulics**, *Trans. ASME*, **51**, p. 83 (1929)

17. Liquids

APPLICATION

Flow of liquids through Crane globe bevel-seat brass valves

FORMULA

$$W = K\sqrt{\rho \Delta P}/1.496$$

NOMENCLATURE

W = Flow, lb./sec.
ρ = Density, lb./cu.ft.
ΔP = Pressure drop across valve, lb./sq.in.
K = Constant, see table

VALUES OF CONSTANT, K

No. Turns Open	Valve Size, In. 1/2	3/4	1	1 1/4
1/4	0.021	0.039	0.051	0.070
1/2	0.043	0.070	0.110	0.150
1	0.077	0.120	0.200	0.270
2	0.099	0.180	0.290	0.410
3	0.104	0.197	0.320	0.480
4	0.100	0.200	0.330	0.510

REFERENCE

Kroll and Fairbanks, *Ind. Eng. Chem.*, **37**, pp. 588–591, (1945)

18. Liquids

APPLICATION

Turbulent isothermal flow of non-compressible fluids in pipes

FORMULAS

$$F = 4fLu^2/2gD$$
$$f = 0.0014 + 0.125/Re^{0.32}$$
$$R_e = Du\rho/\mu$$
$$Z = 0.000672\,\mu$$

REFERENCE

Drew, Koo and McAdams, *Trans. AIChE*, **28**, p. 56 (1933)

NOMENCLATURE

F = Pressure drop, ft. of flowing liquid
f = Friction factor
L = Length of pipe, ft.
u = Velocity, fps.
g = Constant, 32.2 ft./sec.^{2}
D = Diameter of pipe, ft.
Re = Reynolds number
ρ = Density, lb./cu.ft.
μ = Viscosity, lb./sec.-ft.
Z = Viscosity relative to water at 68 F, centipoises

19. Liquids

APPLICATION

Friction loss through non-standard pipe.

PROCEDURE

To obtain friction loss in non-standard pipe, multiply the friction loss in an equivalent length of schedule 40 steel pipe by the appropriate factor in the table.

No.	Pipe Type
I	Schedule 10 steel pipe
II	Rubber-lined schedule 10 steel pipe based on 1/8-in. lining for 4-in. or smaller pipe, 3/16-in. lining for pipe sizes 5-in. and over
III	Saran lined schedule 40 steel pipe
IV	Saran, Parian and Uscolite pipe
V	Hard rubber pipe

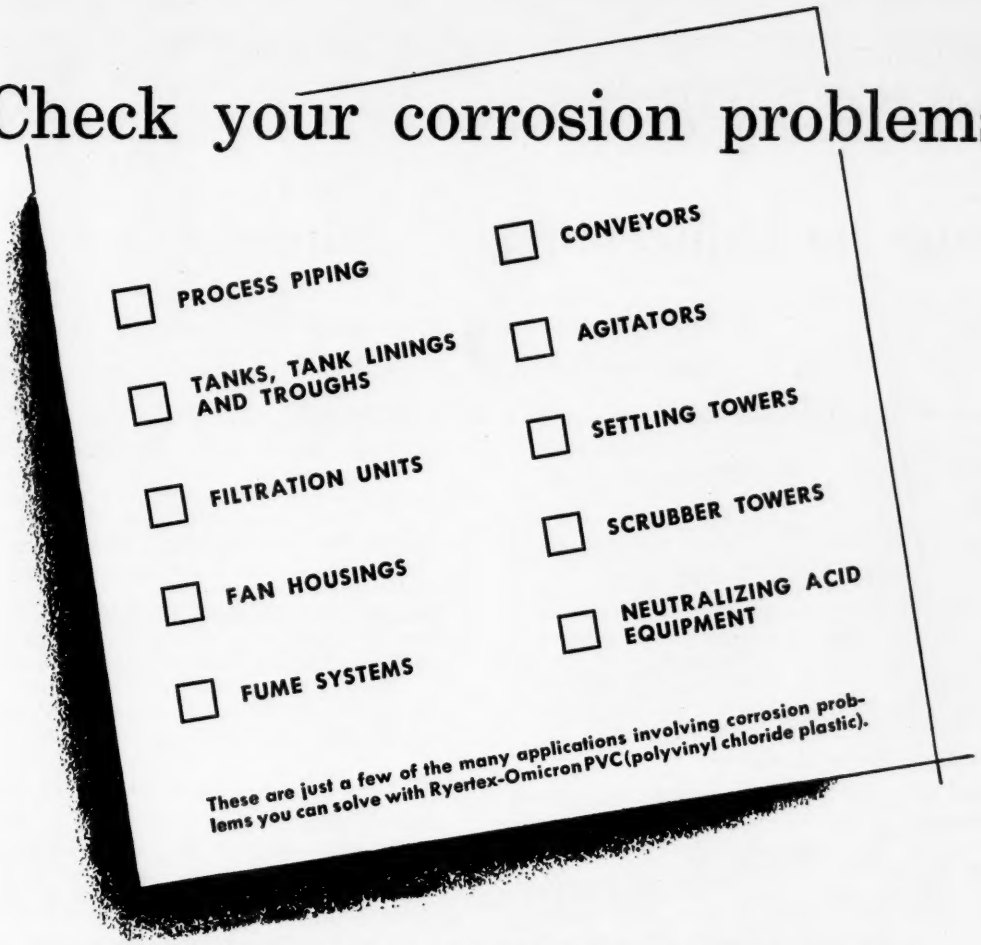
CORRECTION FACTORS FOR NON-STANDARD PIPE

Pipe Size In.	Non-Standard Pipe Types I	II	III	IV	V
1/2	0.677	.....	.....	1.01	1.55
3/4	0.711	.....	.....	0.895	1.30
1	0.804	2.02	4.21	0.842	0.932
1 1/4	0.808	1.42	1.91	0.779	0.870
1 1/2	0.810	1.22	1.29	0.759	0.933
2	0.813	1.01	1.44	0.733	0.863
2 1/2	0.713	0.907	1.04	0.800	0.847
3	0.746	0.814	0.916	0.781	0.916
4	0.760	0.734	0.894	0.758	0.758
5	0.790	0.782	.....	.....	0.721
6	0.795	0.733	0.889	.....	0.776

REFERENCE

Stanley Lenox, *Chem. Processing*, Apr. 1953

Check your corrosion problems



STOP CORROSION CUT COSTS

with RYERTEX-OMICRON PVC

This *original* PVC has set remarkable service records for the past 20 years—and is now available in the United States for the first time—only from Ryerson.

Data on Properties—Ryertex-Omicron PVC resists the attack of more than 250 corrosive solutions and gases, including acids, alkalis and salts. It withstands working temperatures of 185° F. in continuous service; weighs only ⅛ as much as steel—½ as much as aluminum—and can be welded, formed and machined as readily as metal. In addition, this remarkable PVC is non-magnetic, non-sparking and won't support combustion.

Available Shapes—You can get quick shipment of Ryertex-Omicron PVC from Ryerson stocks in sheets, rods, pipe, valves and fittings in a wide range of sizes. Sheets ¼" thick and lighter are fully extruded (not laminated).

Answers to your Questions in New Bulletin—Our bulletin 80-3 tells all about this amazingly versatile material and its applications. Write for your copy today and call your nearby Ryerson plant for any PVC requirement.

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XUM

Design for Liquid-Liquid Equilibrium

Liquid-liquid contacting designs call for skill in handling three-component equilibrium data. Here's a brush-up review.

JAMES O. OSBURN, State University of Iowa, Iowa City, Ia.*

We've already covered three-component equilibrium between vapors and liquids in the two preceding articles (*Chem. Eng.*, Mar. 1957, p. 278 and Apr. 1957, p. 284). In these two discussions we showed convenient methods for representing the equilibrium and we indicated some relationships that you can use to simplify the task of taking data.

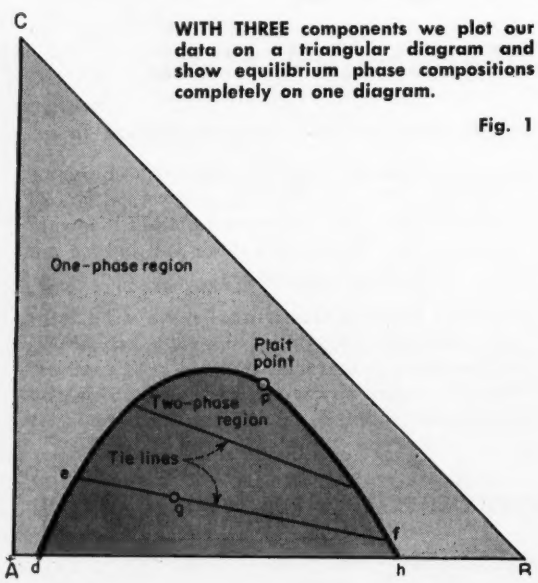
But three-component equilibrium is not restricted to liquid-gas contacting operations in chemical engineering. It can be applied to liquid-liquid contacting as well. In this case we are dealing with equilibrium between liquid phases only.

Phase Rule Shows Similarity

When we apply the phase rule to liquid-liquid equilibrium, we get the same results as we do for vapor-liquid. The phase rule tells nothing about the nature of the phases.

As we showed previously (*Chem. Eng.*, Mar. 1957, p. 278), when we have three components we have $5 - P$ degrees of freedom. By holding temperature and pressure constant, we reduce the degrees of freedom to two for a single phase. So, we can plot our data in two dimensions.

* To meet your author see *Chem. Eng.*, Nov. 1956, p. 415; and Apr. 1957, p. 328.



WITH THREE components we plot our data on a triangular diagram and show equilibrium phase compositions completely on one diagram.

Fig. 1

We don't mind keeping the temperature and pressure constant, because a liquid-liquid contacting operation such as solvent extraction is usually carried out under these conditions. Pressure has a negligible effect on liquid-liquid equilibrium. Temperature does affect it, and we get a different curve for each different temperature.

Just as with any equilibrium, there are limits beyond which we cannot go. For one thing, we must keep the pressure above the vapor pressure of the solution. Also, raising the temperature usually increases the solubility. If we raise the temperature too much, we no longer have two phases.

Triangular Diagrams Show Phases

Although liquid-liquid equilibrium is basically the same as vapor-liquid, in practice we use somewhat different methods for plotting and using our data. It's easier to handle data on liquid-liquid equilibrium because of solubility.

When we have three components, we plot our data on a triangular diagram. In distillation, liquid and vapor compositions in equilibrium may be anywhere on the diagram. But in liquid-liquid equilibrium they are confined to a line on the triangular diagram.

Because of this you can show equilibrium phase compositions completely on a single diagram.

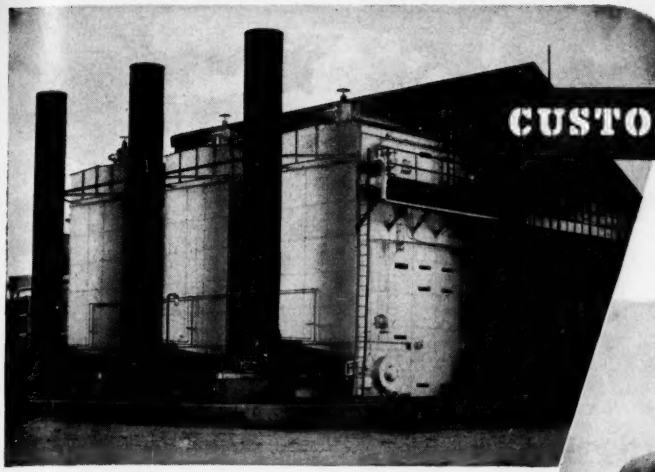
A typical equilibrium diagram (see Fig. 1) shows the compositions of phases in equilibrium. These are represented by the curve shown in color between points *d*, *e*, *p*, *f* and *h* (sometimes called the binodal curve).

The area outside this curve is the one-phase region. Here there are two degrees of freedom and we can vary the composition at will.

The curve represents compositions for two-phase equilibrium, where there is only one degree of freedom. You can vary one composition at will, but the others are fixed thereby. Compositions of one phase lie along the binodal curve between points *d* and *p*; the phase in equilibrium has a composition which lies on the binodal curve between points *p* and *h*.

At *p*, the compositions of the two phases approach the same value. This is the plait point. Although interesting, the plait point is not of any practical use because the densities of the phases in equilibrium at this point are equal—as well as the surface tensions and other physical properties.

If you tried to operate a liquid-liquid contacting



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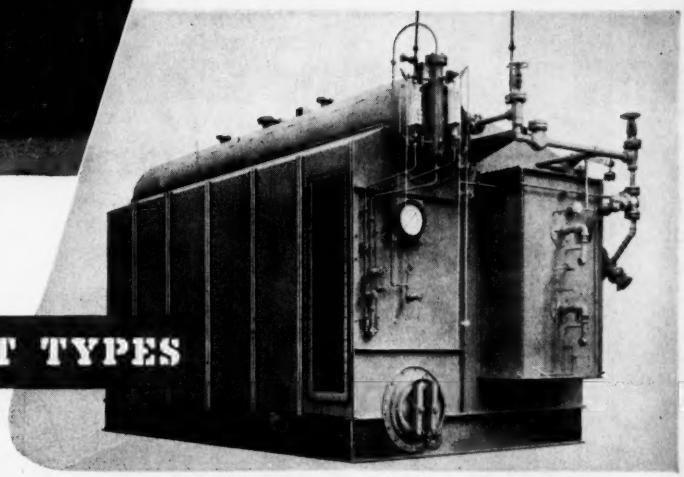

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Conjugate Line Helps You Draw Tie Lines on the . . .

Fig. 1

. . . Equilibrium Diagram

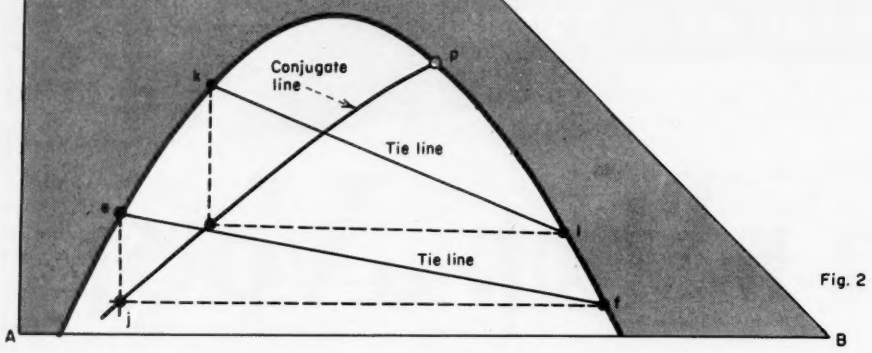

Fig. 2

operation at the plait point, not only would you get no composition change, but also the phases would not separate.

Tie Lines Join Equilibrium Compositions

Phase compositions which are in equilibrium are joined by tie lines on the equilibrium diagram, such as the line between e and f on Fig. 1. Only a few tie lines can be shown—there are an infinite number—since there is a tie line for every point on the binodal curve.

For points where no tie lines are shown, you have to interpolate to find equilibrium compositions. We'll discuss below several methods that will help you accomplish this.

What Happens in the Two-Phase Region?

Any mixture whose composition lies within the area bounded by the binodal curve will separate into two liquid phases. You can find the compositions of the two phases by drawing a tie line through the point that represents the over-all composition of the liquid mixture.

For example, in Fig. 1 the mixture whose over-all composition is represented by point g will separate into two liquid phases with compositions given at points e and f on the binodal curve.

Further, we can calculate the ratio of the amounts of the two phases from the compositions. If the compositions are in weight fractions, we can show that the ratio

$$\frac{\text{Weight of phase } e}{\text{Weight of phase } f} = \frac{\text{Length of line } gf}{\text{Length of line } eg}$$

If the equilibrium diagram has been plotted in mole fractions instead of weight fractions, then the equation above gives the ratio of the moles in each phase.

How to Draw More Tie Lines

We have several methods for interpolating tie lines between those that may have been given with the equilibrium diagram. Someone suggested that all tie lines converge to a single point located outside the diagram. While you might be able to use this idea for some systems, there are many for which it does not hold. We do not recommend its use.

You would do better to use a conjugate line. A conjugate line is merely an aid in drawing tie lines. If you have a few tie lines, you can draw the con-

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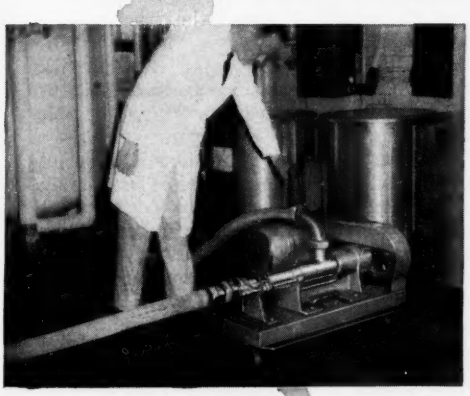

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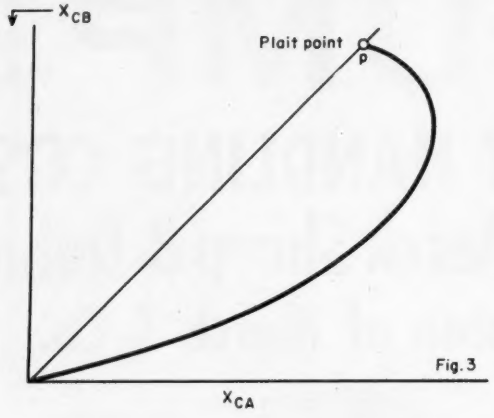

Fig. 3

Sometimes You Get a Solutrope

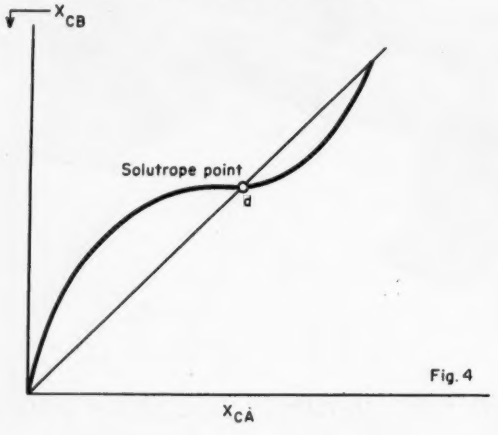

Fig. 4

Equilibrium: Solvent-Free Basis

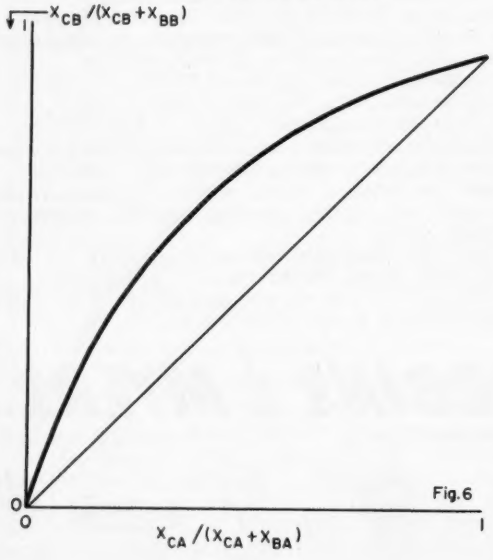

Fig. 6

jugate line and use it to draw in other tie lines.

The conjugate line can be drawn in a number of ways. We've shown a convenient construction in Fig. 2.

From point *e* at one end of the given tie line draw line *ej* in any convenient—but reproducible—direction. Here we have drawn it parallel to one side of the equilibrium diagram. Likewise, draw a line from the other end of the tie line, *f*. These lines must intersect. The point of intersection, *j*, is a point on the conjugate line. From other tie lines draw lines in a similar manner and locate other intersections. Then draw a curve through the intersections.

With this curve you can draw in tie lines by doing the construction in reverse. To locate the other end of the tie line through *k*, draw a line through *k* in the same direction as you drew the line *ej*. Where this line intersects the conjugate line, draw a line parallel to *fj*, intersecting the binodal curve at point *l*.

Distribution Diagrams Are More Convenient

A distribution diagram is more convenient to work with than the triangular equilibrium diagram. On the auxiliary distribution diagram the equilibrium compositions of only one of the three components is plotted. We usually plot the composition of the solute, the substance which is miscible with both other components.

This is purely a matter of convenience in making calculations, though, and the other components could be used just as well.

In Fig. 3 we have plotted the distribution diagram for the substances in Fig. 2. You ought to be familiar with the shorthand notation for three-component, two-phase compositions:

X_{CA} is the weight fraction of *C* in the phase that contains a high percentage of *A*.

X_{CB} is the same for the phase containing mostly *B*.

Likewise, X_{BB} would represent the fraction of *B* in the *B*-rich phase.

Point *p* represents the plait point. The distribution diagram doesn't tell everything about the phase compositions, so we still need the triangular solubility diagram in addition.

Sometimes we have dilute solutions of a solute in two solvents which are immiscible. Then the distribution diagram is all we need.

We say that the distribution favors one or the other of the solvents. In Fig. 3, the distribution favors solvent *A*. Although we would be able to carry out a physical process where we extract *C* from *A* to *B*, it would take more solvent to do the job.

Distribution Coefficient Aids Calculation

We can now define a distribution coefficient that will be useful in liquid-liquid extraction calculations:

$$m = X_{CB}/X_{CA}$$

The distribution coefficient is approximately constant for dilute solutions, but for more concentrated ones it changes a great deal.

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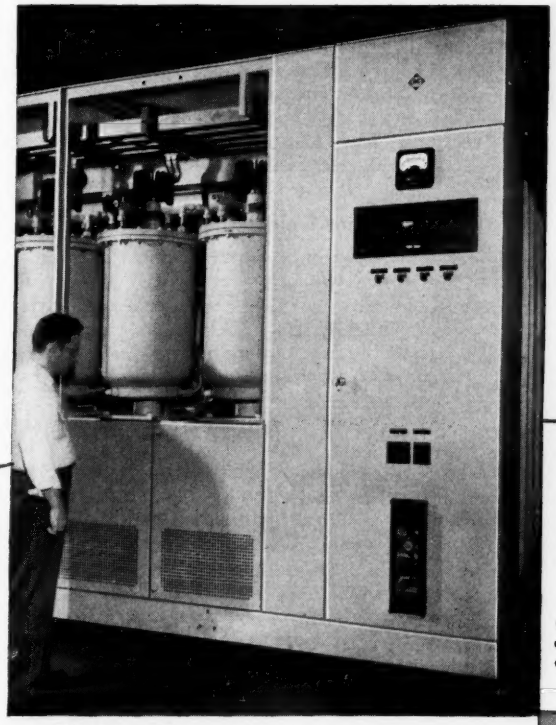

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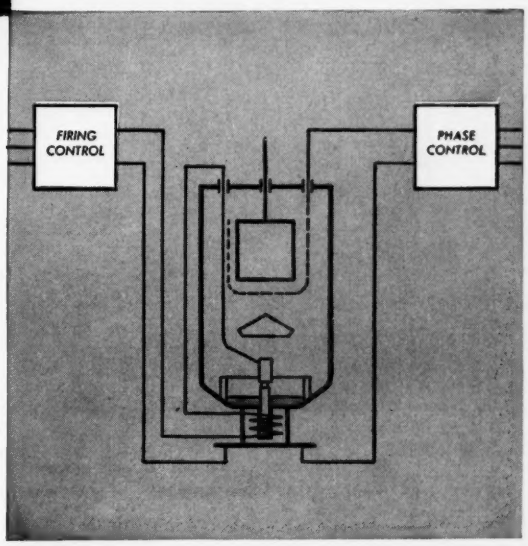

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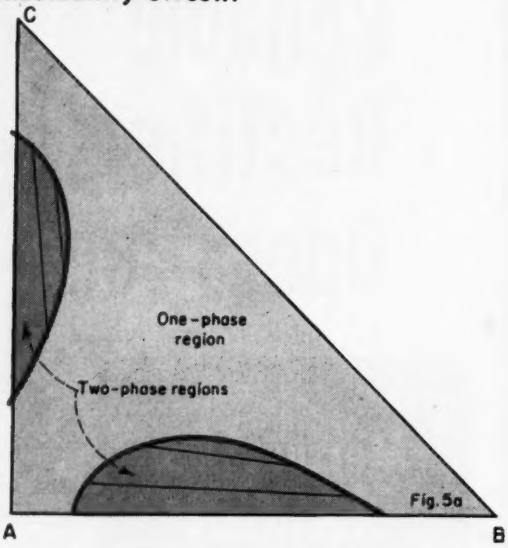
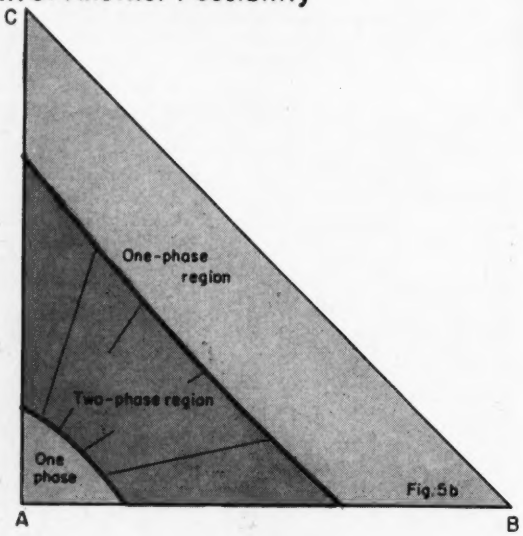


...Or Another Possibility



Solutropes Resemble Azeotropes

In some systems we find a condition which resembles azeotrope formation in vapor-liquid equilibrium. When the distribution curve crosses the 45-degree line as at point d on Fig. 4, we have this situation.

Here the equilibrium changes. Below d it is more favorable to B; above d it is less favorable. The distribution coefficient is equal to 1.0 at d and neither solvent is favored.

Although you would want to know about it if there were a solutrope in a system you were working with, it's not nearly as serious as an azeotrope would be in a distillation equilibrium.

With an azeotrope you can't make any separation; with a solutrope you can. You just need more solvent. The composition of the two phases are the same in an azeotrope; with a solutrope only one of the components has the same concentration in both phases. The other two concentrations are different.

Actually, you may be able to make the solutrope disappear by using mole fractions instead of weight fractions. The existence of solutropes seems to be just a curious coincidence.

Other Tie-Line Correlations

Besides the simple distribution diagram, many other methods have been proposed for correlating tie-line data. The object of these correlations is to get a straight line. This helps you smooth the data, but you will do more work using the data.

Some of the correlation plots are these:

- Bachman. Plot X_{BB} vs. the ratio of X_{BB}/X_{AA}. See *Ind. & Eng. Chem., Anal. Ed.*, Vol. 12, p. 38 (1940).
- Othmer and Tobias. Plot $(1 - X_{BB})/X_{BB}$ against $(1 - X_{AA})/X_{AA}$ on log paper. See *Ind. & Eng. Chem.*, Vol. 34, p. 693 (1942).
- Hand. Plot X_{CB}/X_{BB} against the ratio X_{CA}/X_{AA} on log paper. See *J. Phys. Chem.*, Vol. 34, p. 1,961 (1930).

Later in this discussion we'll describe one method, in addition to these three, that is of great usefulness.

There Are Many Solubility Diagrams

So far we have based all the discussion on a system in which one pair of components is partly miscible, and the other two are completely miscible. This is sometimes referred to as a "Type 1 diagram." It is the simplest case, because if all the pairs were miscible, we wouldn't have phase equilibrium.

Now, if two of the pairs show insolubility, the resulting three-component diagram looks quite different. There are two possibilities. One, shown in Fig. 5a resembles a Type 1 diagram. Addition of a third component to either insoluble pair increases the solubility, up to the point where there is complete miscibility. There are two two-phase regions, each with its own set of tie lines, distribution curve and plait point.

In the other case the third component lowers the solubility, and the two-phase regions merge as shown in Fig. 5b. Here there are two one-phase regions, and one two-phase region. There is no plait point, since the compositions of the two phases never approach each other. Some have called this the "Type 2 diagram."

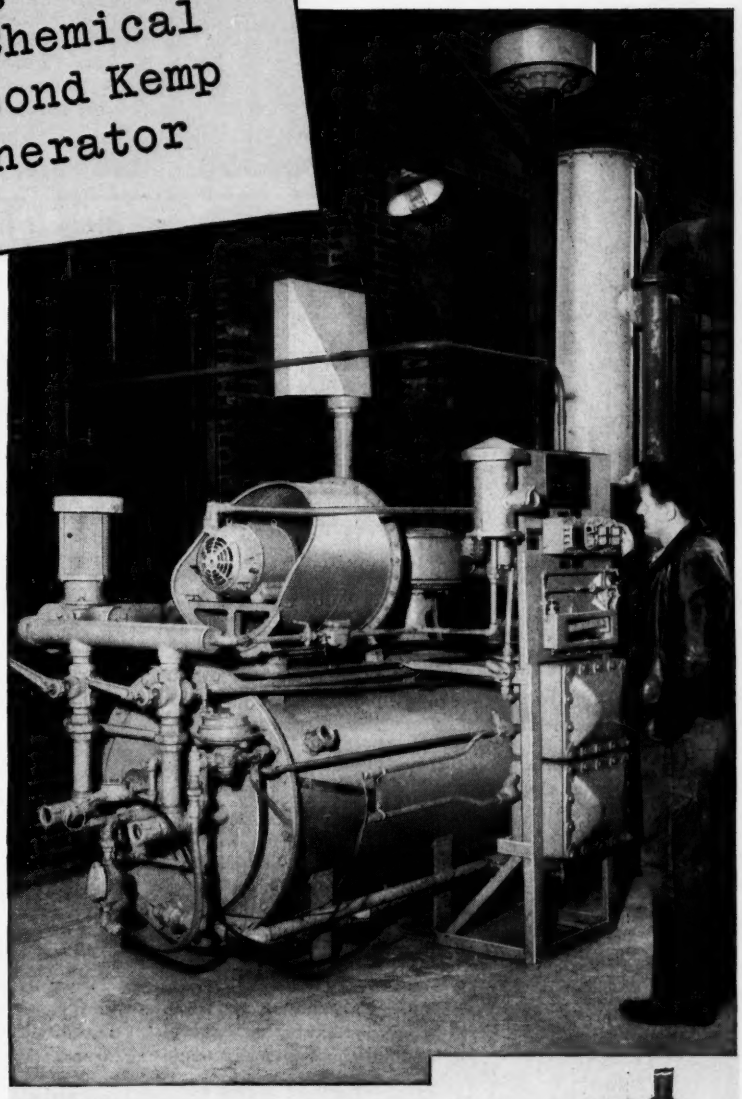
The most convenient way of representing a Type 2 distribution is on a solvent-free basis. In this connection the solvent is A, the component which forms immiscible mixtures with both of the other components. On an A-free basis, then, a composition is represented by $X_C/(X_C + X_B)$. Now if we plot the distribution as:

$$\frac{X_{CB}}{X_{CB} + X_{BB}} \text{ vs. } \frac{X_{CA}}{X_{CA} + X_{BA}}$$

we get a diagram similar to Fig. 6 on p. 280. This diagram looks a lot like a vapor-liquid equilibrium

Case No. 58

Results Bring Re-Order from Heyden Chemical Corp. for Second Kemp Inert Gas Generator



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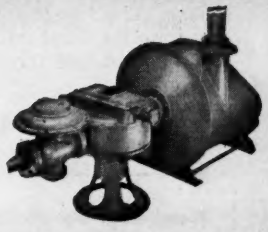

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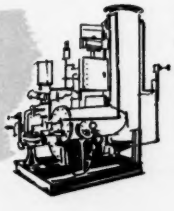

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There May Be Three Phases

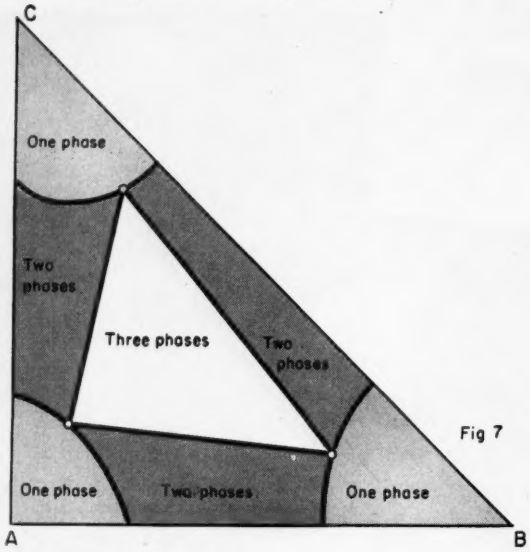

Fig 7

diagram, and this similarity has been used by Maloney and Schubert, as described in *Trans. AIChE*, Vol. 46, p. 741 (1940), in a method for designing extraction equipment that resembles the Ponchon-Savarit method.

Because of the simplicity which this method of plotting imparts to the equilibrium diagram, we have put Fig. 6 on the same panel as Fig. 3, for the purpose of comparison.

If all three pairs of components have regions of immiscibility, the equilibrium diagrams may be of several different types. In one of these, Fig. 7, we have a three-phase region. With three phases—at constant temperature and pressure—there are zero degrees of freedom, and all the compositions are fixed.

Three-phase compositions are shown at points in circles. Any mixture in the three-phase region will separate into three phases of these compositions. The two-phase and one-phase regions are shown on the diagram.

We do not find three pairs of immiscible liquids very often.

Selectivity Identifies Good Solvents

If we want to know whether a solvent is a good one for an extraction process, we can tell to a certain extent by the distribution coefficient.

Another ratio, the selectivity, tells more. We define the selectivity of B for C as follows:

$$\beta_{BC} = \frac{X_{CB}/X_{AB}}{X_{CA}/X_{AA}}$$

If a process is going to be satisfactory, the selectivity of the solvent must be greater than unity. Unlike the distribution coefficient, the selectivity is the same when we use mole fractions as when we use weight fractions.

How to Predict Distribution

A lot of liquid-liquid equilibrium data have been published in recent years. Most authors now give tie-line data, as well. But in many of the older articles this is not done.

We can use activity coefficients and the van Laar equation to predict the distribution of a solute between two solvents, if we have the solubility curve. The activity coefficient may be obtained from any of these sources:

- Binary vapor-liquid equilibrium data.
- Azeotropic data.
- Two-component solubility data.

Methods for making the calculations are described by R. E. Treybal in "Liquid Extraction," Chapter 3, McGraw-Hill Book Co., Inc., New York (1951). You can use the results to help you choose a solvent that will be good for the required extraction job. However, the results are generally not reliable enough to use for design.

Treybal also explains how you can even calculate the solubility curve. But the method is difficult and the accuracy of the results very uncertain.

Next Month: Four Components

So far we've discussed two applications of three-component equilibrium. When there are more than three components, we generally have to make some assumptions to put our data into usable form.

One exception is four-component liquid-liquid equilibrium. We can work with this and represent the data completely without assumptions. This is the topic of our next installment.

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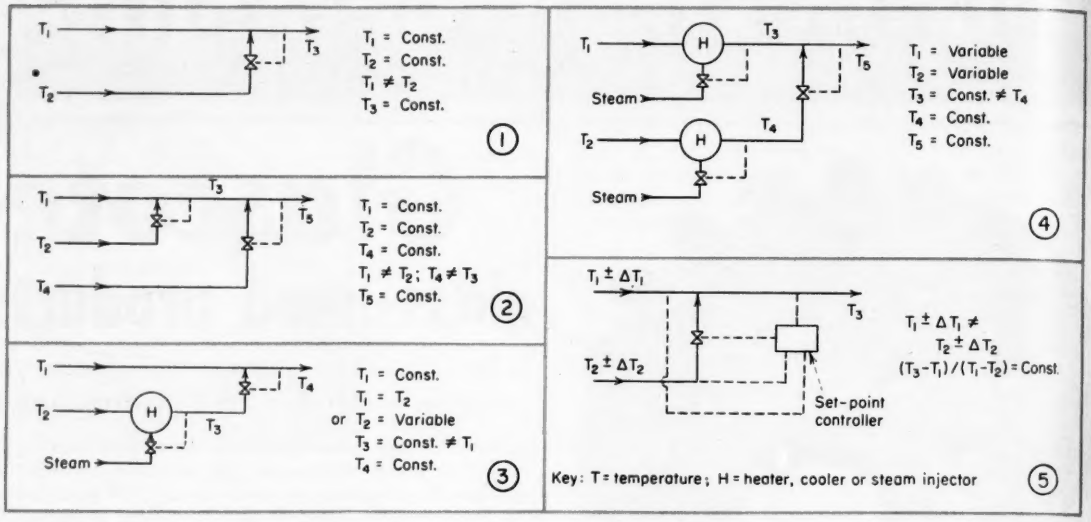

★ **Winner of February Contest**

Proportion Your Flows Without Meters

When fluid streams are hard to meter you can proportion them on the basis of temperature if temperatures differ.

Robert K. Multer
Vice-President, Architectural Tiling Co., Inc., Keyport, N. J.

With many fluids, accurate metering offers difficult problems. There are cases, therefore, where a method for proportioning two or more continuous flows without metering would be extremely useful. If the streams are of different temperatures, or can be heated or cooled so the temperatures will be different, then they can be mixed and the proportions controlled automatically on the basis of the temperature of the resulting mixture.

For this method to work satisfactorily it is not necessary for the flow rates to remain constant. The primary stream may be variable in quantity, or it may be desired to vary the output stream with a hand valve. It is only necessary that the secondary stream or streams be available at sufficient flow rate to provide the desired proportion for the maximum possible flow rate of the primary stream. This is necessary because the control hook-ups shown cannot distinguish a shortage of the secondary stream.

However, it is possible to design the various systems with

★ **Winner of March Contest—William B. Speir**

Do-It-Yourself Models for Preliminary Layout

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$50 Prize for a Good Idea—Until further notice the Editors of *Chemical Engineering* will award $50 cash each month to the author of the best short article received that month and accepted for the Plant Notebook.

Each month's winner will be announced in the issue of the second following month, and published the third following month.

$100 Annual Prize—At the end of each year the monthly winners will be rejudged and the year's best winner awarded an additional $100.

How to Enter Contest—Any reader (except McGraw-Hill employees) may submit as many contest entries as he wishes. Acceptable material must be previously unpublished and should be short, preferably not over 500 words, but illustrated if possible. Acceptable non-winning articles will be published at space rates ($10 min.).

Articles may deal with plant or production "kinks," or novel means of presenting useful data, of interest to chemical engineers. Address Plant Notebook Editor, *Chemical Engineering*, 330 West 42nd St., New York 36, N. Y.

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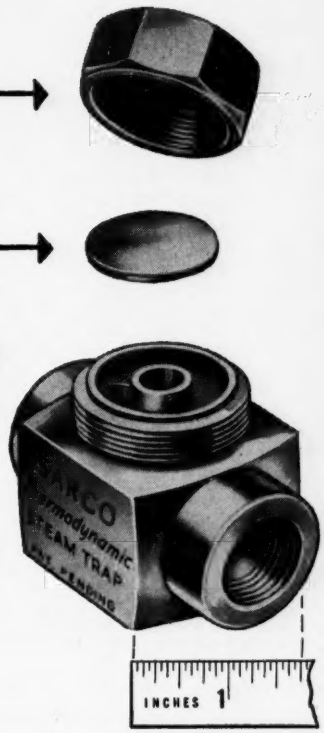

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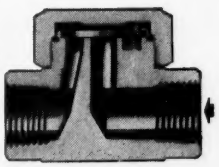

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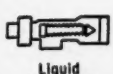

Liquid Expansion Steam Traps

Camlift Bucket Steam Traps

low-flow alarms so that a shortage of one feed stream will operate an alarm or shut down the system. A shortage in the secondary stream can be detected automatically and used for alarm or shutdown by alarm contacts in the controller which operate only if the product stream temperature cannot be brought to the set point regardless of how far the control valve is opened.

There are several hook-ups possible, depending on the number of feed streams and whether their temperatures are constant or variable.

Case 1—This case (Fig. 1) has two feed streams of different but constant temperature. Here the mixing ratio can be controlled by a single control valve in one stream, actuated by a temperature controller responding to the temperature of the output stream.

While it is theoretically simple to calculate the product stream temperature for each mixing ratio knowing the feed stream temperatures, flow rates, specific heats and heats of mixing, there are probable unknowns in the equation such as heat losses and possible inaccuracies in the thermal coefficients. Hence it is better to calibrate the system at the flow rates desired.

Case 2—More than two streams can be handled if each secondary stream is brought in one at a time, and a separate temperature controller provided for each, as in Fig. 2. The temperatures of the various streams may be any constant value, provided only that they differ sufficiently from the temperature of the mixed stream from the previous stage. For example, with three streams, T_1 and T_2 must differ, but T_4 may equal either T_1 or T_2, so long as it differs sufficiently from T_3.

Case 3—This case can handle either of two situations. In a two-stream system if the temperatures are equal, or if one of them is constant, but the other variable, then the use of a heater or cooler in one stream will permit the system to operate as in Case 1. In Fig. 3 temperature T_3 may either be variable or equal to T_1. The method here is to regulate the temperature of stream 2 to a new constant temperature T_3, either by heating or by cooling. In this case T_3 must be different than T_1.

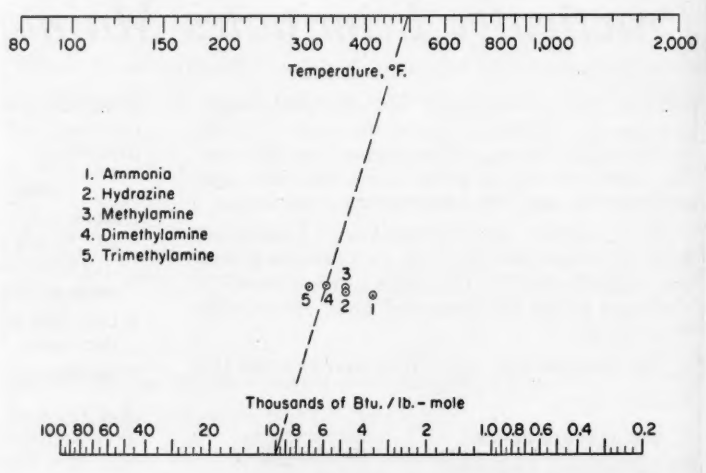
Case 4—This case differs from case 3 only in the fact that both feed stream temperatures are variable. In Fig. 4 the solution is to heat or cool both feed streams to new constant values T_3 and T_4 which differ from each other.

Case 5—In the earlier cases we noted that the flow rates did not need to be constant, but that the temperatures of the various streams either had to be constant and unequal, or else one or more of the streams had to be heated or cooled so that the temperatures would become constant and unequal. A still more "elegant" method can be worked out, using a slightly more complicated controller, which requires neither constant flows nor constant temperatures, and does not involve heating or cooling of the streams.

This method is shown in Fig. 5. The incoming stream temperatures T_1 and T_2 can vary independently of each other. The output temperature T_3 will also vary, which differs from the situation in the earlier cases where this temperature was always constant. The controller measures the three temperatures T_1, T_2 and T_3 and adjusts the flow of stream 2 so as to hold the ratio $(T_3 - T_1)/(T_1 - T_2)$ constant.

This system will work so long as the specific heats, heat of mixing and heat losses remain constant, and the instantaneous stream temperatures do not become equal. Because no heating equipment is needed it should prove less costly than cases 3 and 4 in spite of the more expensive controller needed.

These systems will be most useful in applications where flow rate measurement is difficult or impossible. However, temperature control generally seems cheaper and more reliable than flow control, so the scheme should have wide usefulness.

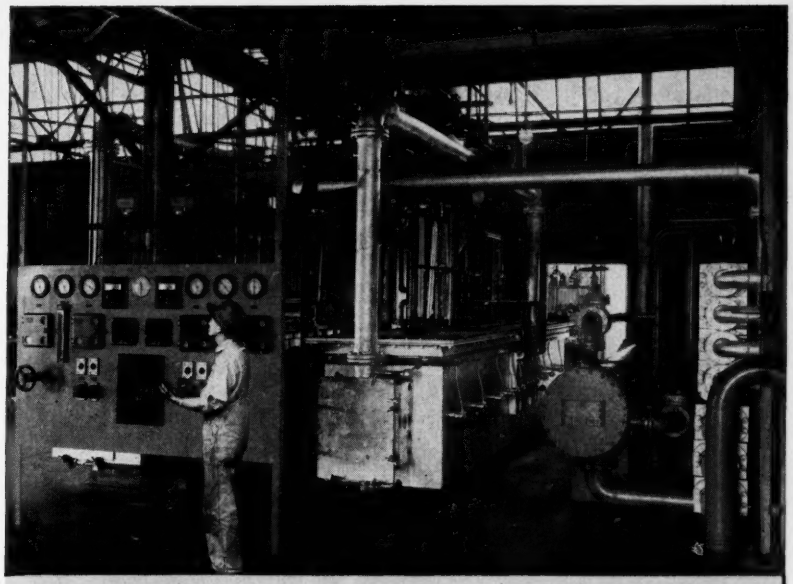

80 100 150 200 300 400 600 800 1,000 2,000
Temperature, °F.
1. Ammonia
2. Hydrazine
3. Methylamine
4. Dimethylamine
5. Trimethylamine
Thousands of Btu. / lb. - mole
100 80 60 40 20 10 8 6 4 2 1.0 0.8 0.6 0.4 0.2

Total Heats of Nitrogen Compounds

D. S. Davis
Professor of Engineering, University of Alabama, Tuscaloosa, Ala.

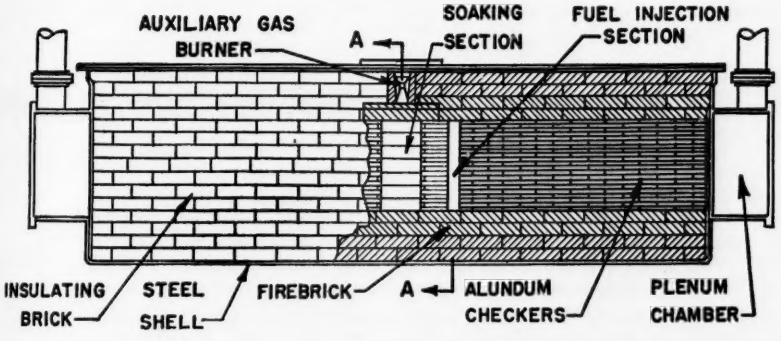
The line coordinate chart presented above enhances the value of data on the enthalpies of five nitrogen compounds which were given by Kobe and Harrison (*Petrol. Refr.*, 33, 161, Nov. 1954). After conversion to English units the chart is based on the equation: $\Delta H = a(t + 10^{0.849 - 0.00283t})^b$, where ΔH is enthalpy in

ALUNDUM* checkers give 4 years continuous service



In this double regenerative furnace the Wulff Process Company of Huntington Park, Calif., produces acetylene starting with propane or other petroleum gas as the raw material. The Wulff Company reports that ALUNDUM checkers in this equipment are still going strong after continuous service, five days a week for more than four years.

Wulff Process Company says no replacement required in acetylene producing furnaces



Cross sectional diagram shows, in yellow, the location of Norton ALUNDUM checkers in the Wulff furnace. Air, preheated in the first ALUNDUM regenerator to 1800° F., is mixed with gas in the fuel injection section producing high temperatures and transferring this heat to the second regenerator. A propane-steam mixture is then passed in the opposite direction through the regenerators, heating and cracking in the second and cooling in the first. The heating and cracking cycles are both of one minute duration. ALUNDUM checkers take this extreme cyclic thermal stress and provide efficient, low cost operation.

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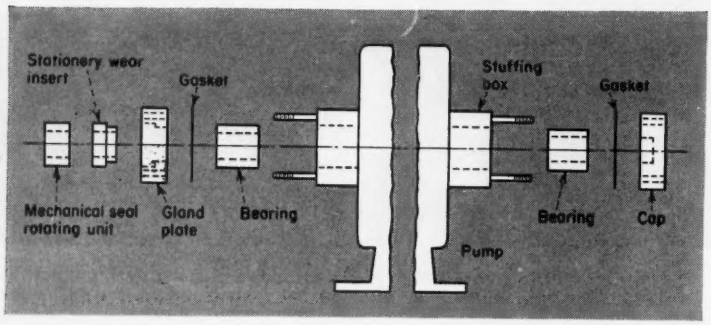
kg.-cal./gm.-mole; t is temperature, °C.; and a and b are both constants. They depend on the compound.

Use of the chart is illustrated as follows: What is the enthalpy of dimethylamine at 500 F.? Connect 500 F. and Gage Point (4) for dimethylamine with a straight line and read the intersection with the enthalpy scale as 10,000 Btu./lb.-mole (or 10,000/1,800 = 5.53 kg.-cal./gm.-mole).



How to Add a Seal to a Rotary Pump

Robert D. Ireland
Maintenance Engineer, Sharples Div., Penn Salt Mfg. Co. Wyandotte, Mich.

We were having trouble with leakage of chemicals from the stuffing boxes of several Blackmer rotary swinging-vane pumps. The obvious answer was to install mechanical seals, but the problem was complicated by the fact that the pump has a through shaft with two stuffing boxes, hence would require two mechanical seals.

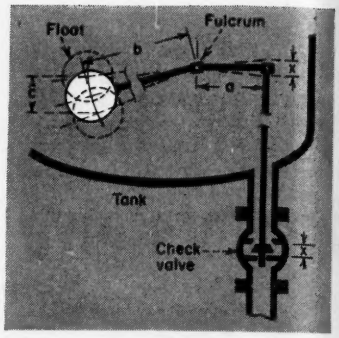
The method we used made it possible to use only one seal and thus reduce the cost considerably. The pumps converted have been of several sizes and have included steam-jacketed pumps. They have successfully handled such materials as Nos. 3 and 4 fuel oils, secondary amyl phenol, amyl napthalene and naphthalene.

Here is how the pumps were altered. We removed and discarded the packing glands and pressed bronze Oilite bearings into the stuffing boxes. These bearings were of commercially available size and required no change in length, internal or external diameter, or in the stuffing box itself. They thus replaced that section of the bronzed packing glands which is used as a bearing in Blackmer pumps.

As shown at the right of the drawing, we fabricated a cap from scrap metal and secured it over a gasket fitted to the outboard end of the pump by means of the existing stuffing box studs. The cap was recessed so that the projecting end of the pump shaft would not have to be cut off, enabling us to continue using standard Blackmer shafts.

The arrangement used on the inboard or driven end of the shaft to accommodate the mechanical seal is shown at the left of the drawing. We fabricated a gland plate of scrap steel, recessed to hold the stationary wear insert of the seal, installing this over a gasket by means of the stuffing box studs. The rotating member of a standard outside-type rotating seal was then slipped over and secured to the shaft.

Correction—Through a transcription error the crest-length scale of the chart on p. 284, February 1957, was labeled inches, where it should have been feet.



Using a Check Valve For Level Control

E. N. Currlin
General Supervisor of Antibiotic Production
E. R. Squibb & Sons, S. A.
San Paulo, Brazil.

It is easy to make a simple and inexpensive level controller of the out-flow type as shown in the illustration, using an ordinary vertical check valve, inverted, as the valve element. By turning the body of the valve upside down, it can serve as an in-flow level controller, shutting at a desired high level.

The disk of the check valve is connected to a float by means of a metal rod and a lever system. In designing the lever system we are interested in the volume to be controlled between the high and low levels. This is reflected in the vertical distance of float movement which, when reduced by the lever, should give a movement of the valve disk no greater than from the full-open to full-closed positions. Otherwise, the float system may be put under strain.

Having measured x, the maximum travel of the valve disk, we note that c, the height of float travel, is related to x by the expression $c = x(b/a)$. By choosing the ratio b/a properly we can secure any desired value of c.

Most likely c will be determined by the volume of tank contents we want emptied between the high and low limits. Suppose, for example, we have a vertical cylindrical tank 4 ft. in diameter and want c to correspond to 50 gal. The capacity is

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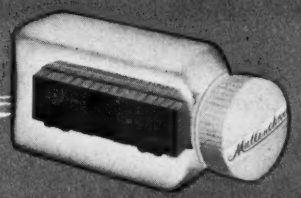

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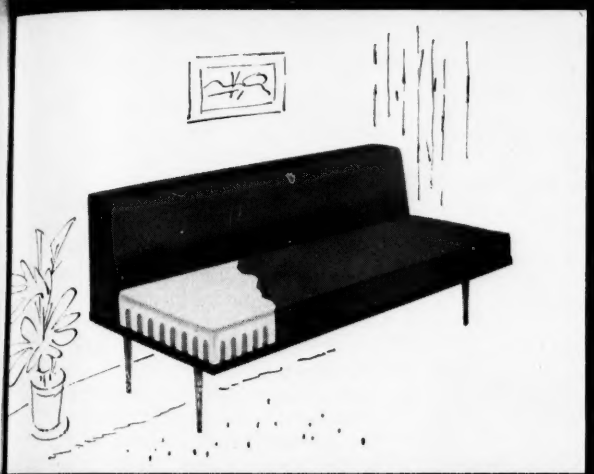

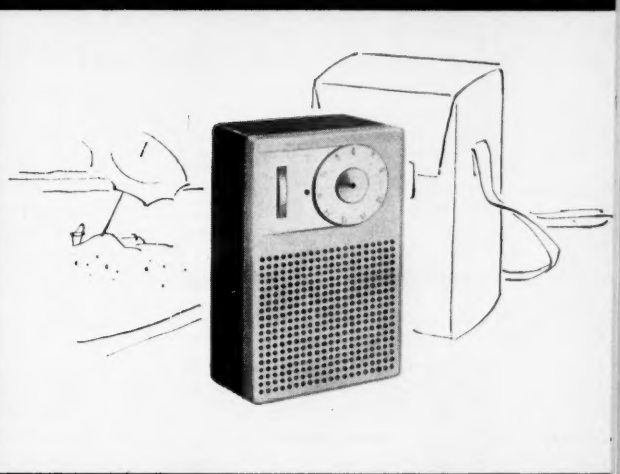

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7.5 $D^2\pi/4 = 94$ gal. per ft. of height, so $c = 50/94 = 0.532$ ft. If $x = 0.5$ in., then $c/x = 0.532 \times 12/0.5 = b/a = 12.8$, meaning that arm b should be 12.8 times the length of arm a.

How to Find Percent of Solids in a Slurry

Linden E. Shipley
Research Engineer
The Edward Orton Jr. Ceramic Foundation, Columbus, Ohio.

In the August 1956 issue the Plant Notebook carried an unnecessarily complicated method (p. 230) for finding the percentage of solids in a slurry. A much simpler version of this method has been in use in the ceramic industry for generations, under the name of Brongniart's formula. This formula is derived as follows:

Let P equal the weight of any volume V of slurry. Then P equals the sum of the weight D of the solids present, plus the weight W of an equal volume V of water, less the weight D/G of the water displaced by the solid. Here G is the true specific gravity of the solid. That is

$$P = D + W - (D/G)$$

and $$D - (D/G) = D\,(1 - 1/G) = P - W$$

Hence $$D = (P - W)/(1 - 1/G)$$

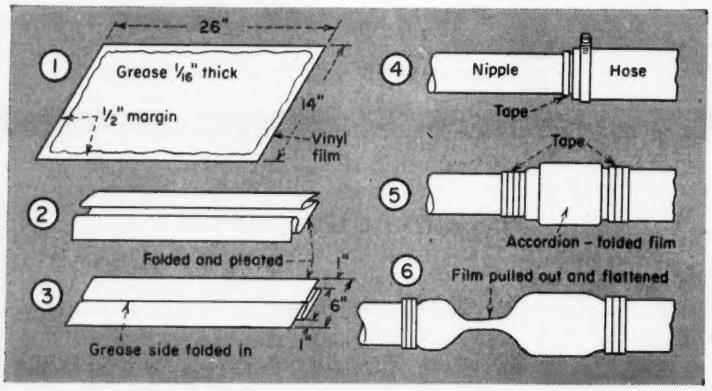
and $$D = \frac{(P - W)\,G}{G - 1}$$

Where the liquid is not water, the formula becomes:

$$D = \frac{(P - W)\,G}{G - \rho}$$

where ρ is the specific gravity of the liquid.

The method requires no graphical work and applies to either the English or the metric system. It is unnecessary to have an accurately graduated volume. Simply weigh the same convenient volume of water and of slurry (a pint, a quart, a gallon, a liter, etc.), and apply the formula using the true specific gravities of solid and liquid.



Safe Way to Disconnect "Hot" Hose Lines

Herbert P. Cantelow
Radiation Laboratory, University of California, Berkeley, Calif.

Safe disconnection of radioactively contaminated hose lines can be surprisingly difficult and yet is a frequent problem in radiochemical activities. Although hose lines may be carefully slipped off the nipples in low-level work, a much better method is needed when many curies of activity are handled, since escape of even a small fraction of the contaminant in the lines would be serious.

Recently several thousand curies of a highly dangerous alpha emitter and its fission products were processed in four "hot cells." After processing it was necessary to disconnect the 2-in. process gas lines from the cells to allow disposal of the equipment.

Originally it had been planned to weld shut a section of plasticized vinyl tubing by radio-frequency heating, then cut through the welded section. This plan failed, however, because of degradation of the material from radiation and chemical attack, so another method had to be found. The method worked out as a substitute was completely effective in the disconnection of 15 joints, without escape of any trace of contaminant from the hoses. It was simple, used no special techniques and required only readily available materials.

The diagram shows several of the steps. A 14 x 26-in. sheet of 0.004-in. vinyl film (sketch 1) was smeared on one side with a 1/16-in. coating of ball-bearing grease (automobile front-wheel grease), except for a 1/2-in. margin. Such grease is just right for the application, having high cohesiveness and adhesiveness to make a good seal, together with lubricating qualities that allow the sheet to slide easily. The sheet was folded lengthwise by pleating the middle 8 in., leaving the grease inside and a 1-in. width free along each side (sketches 2 and 3).

We then removed the hose clamp holding the hose on the nipple and wrapped the nipple end abutting the hose with a layer of Scotch No. 400 double-control pressure-sensitive tape (sketch 4). The folded membrane, grease side in, was then wrapped three full turns around the joint, as in sketch 5, one edge being taped to the nipple, the other to the hose. For this purpose we used Scotch No. 33 vinyl electrician's tape.

The last step was to pull the hose out of the nipple (sketch 6). As this is done the pleat unfolds, allowing about a 5-in. separation between hose and nipple. The free center section of film can then be squeezed together gently with padded tongs to flatten it, then it is cut apart with scissors. Each end is thus sealed with the greased film, but extra protection can be provided by adding another stronger seal such as a rubber glove.

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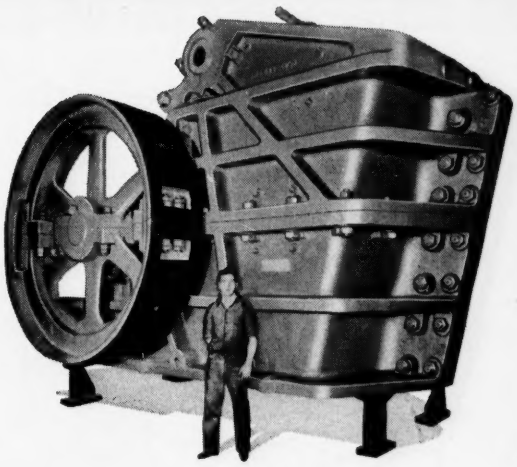

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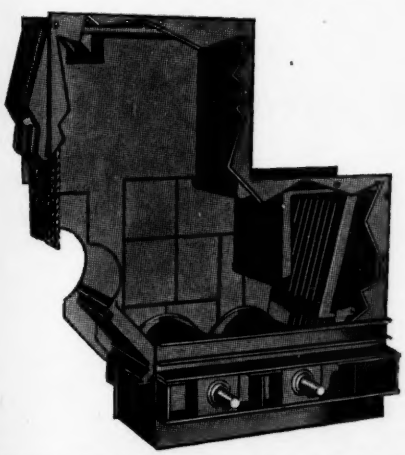

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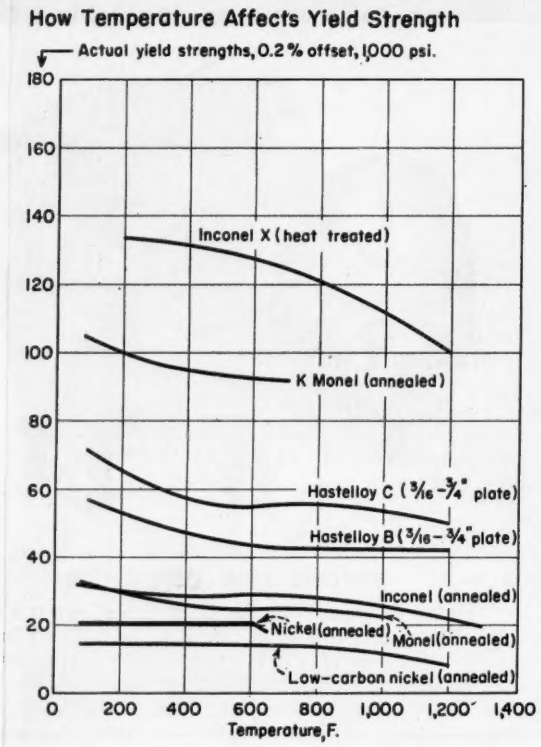
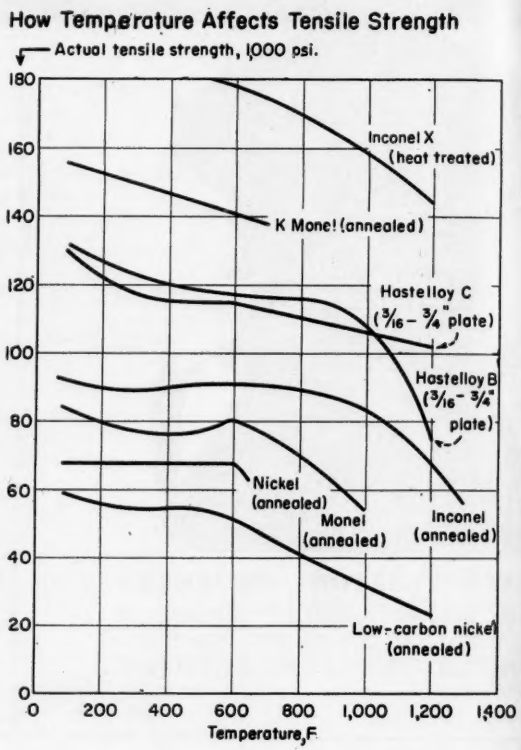




Ni Alloys Shine at High Temperatures

Ni and Ni alloys have excellent mechanical properties at high temperature for pressure vessels. Here is data to help you choose best alloy.

R. M. Wilson, Jr. and W. F. Burchfield, International Nickel Co., N. Y. C.

Nickel and high-nickel alloys are finding increasing use in chemical pressure vessels and auxiliary equipment.

Higher operating temperatures and pressures, and the ever insistent demands for higher purities, have centered interest not only on the corrosion resistance of nickel alloys, but also on strength and hardness at high and low temperatures.

An understanding of these properties will point up advantages and disadvantages, and help you apply these new alloys correctly and economically.

Pressure vessels have been constructed of nickel, low-carbon nickel, Monel, Inconel, Hastelloy B and C, K Monel and Inconel X. Only the first six have been recognized by the ASME code for use in pressure vessels.

It should be noted that not one of these materials shows brittle transition in sub-zero temperatures (liquid nitrogen at −423 F.) In fact, their tensile properties increase as the temperature falls, while impact resistance, reduction of area, and ductility show little or no change.

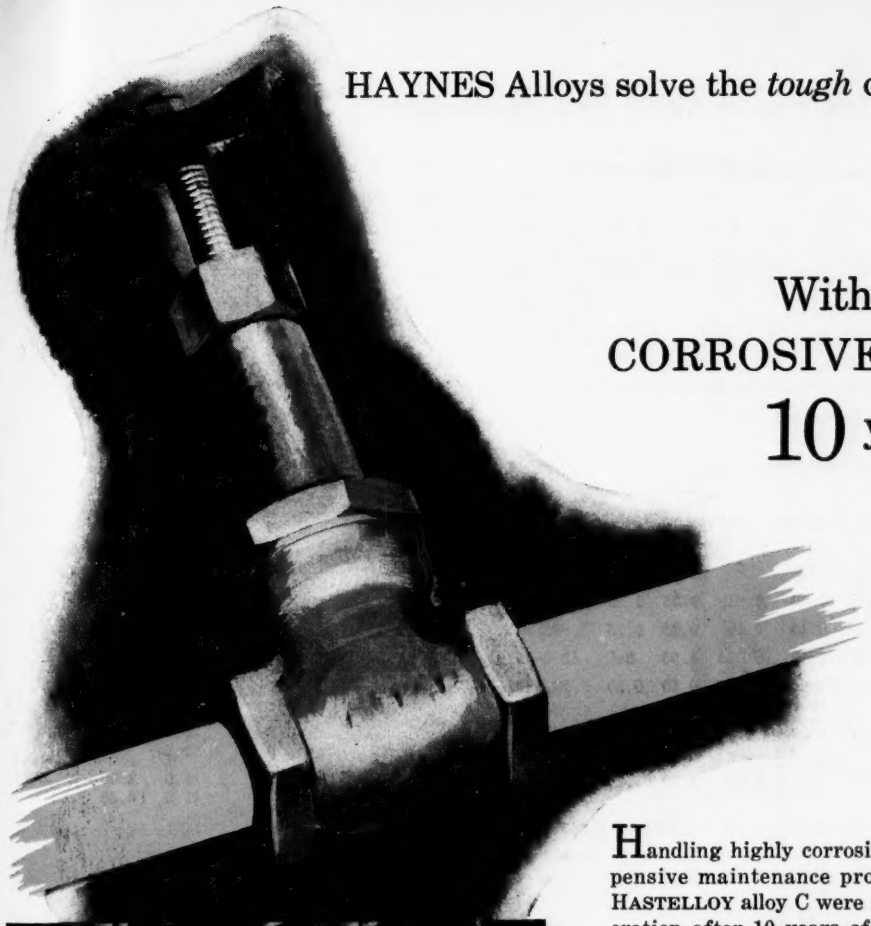
Advantages of High-Ni Alloys

In nickel with 0.15% max. carbon, the carbon strengthens nickel as it does steel. But unlike steel, no carbides of nickel form.

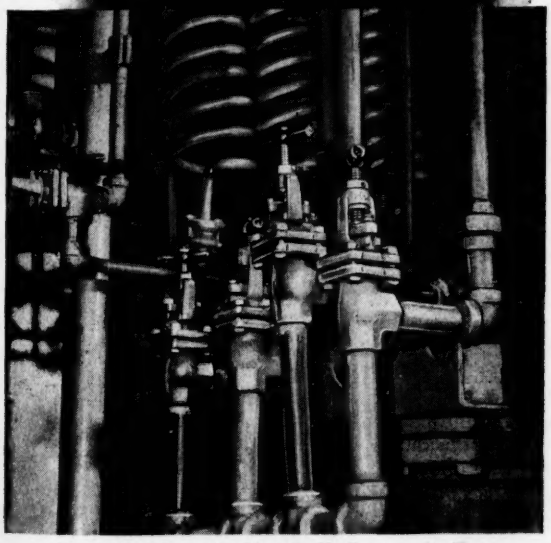
However, when heated above 600 F. for long periods, graphitization and lower ductility result. Thus use of nickel is limited to temperatures below 600 F. (see tensile and yield strength curves).

Nickel is highly resistant to alkali corrosion. It forms a passive oxide film. While acid oxi-

HAYNES Alloys solve the *tough* corrosion problems



Withstands
CORROSIVE CHLORINE
10 years!



. . . Handling Corrosive Liquids No Longer An Expensive Problem. The 30 valves in the chlorine pipe line required constant maintenance. Before valves made of HASTELLOY alloy C were installed, 3 to 4 of the thirty valves had to be replaced each week. Now . . . maintenance is simply periodic inspection and repacking.

Handling highly corrosive liquid chlorine was an expensive maintenance problem—until valves made of HASTELLOY alloy C were installed. They are still in operation after 10 years of service and are expected to last indefinitely.

This is just one of the many corrosion difficulties met by HAYNES Alloys. They also have excellent resistance to hot mineral acids, strongly oxidizing salts, powerful gaseous oxidants, and combinations of these media over a wide range of temperatures and concentrations.

The booklet "HASTELLOY Corrosion-Resistant Alloys" describes these alloys that are solving corrosion problems in many industries—write for your copy.

HAYNES STELLITE COMPANY
A Division of Union Carbide and Carbon Corporation
UCC
General Offices and Works, Kokomo, Indiana
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Chicago • Cleveland • Detroit • Houston • Los Angeles
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HAYNES TRADE-MARK ALLOYS

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Important Physical Properties of Nickel Alloy Metals—Table I

	Nickel	Low C Nickel	Monel	Inconel	Hastelloy B	Hastelloy C	K Monel	Inconel X
Density, lb./cu.in.	0.321	0.321	0.319	0.307	0.334	0.323	0.306	0.300
Specific gravity	8.89	8.89	8.84	8.51	9.24	9.94	8.47	8.30
Melting range, F.	2,615–2,635	2,615–2,635	2,370–2,460	2,540–2,600	2,410–2,460	2,320–2,380	2,400–2,460	2,540–2,600
Specific heat, 32–212 F., Btu/lb./F.	0.11	0.11	0.13	0.11	0.091	0.092	0.13	0.105
Thermal conduct., 32-212F., Btu./sq.ft./hr./F./in.	420	420	180	104	78.5	87	130	102
Tensile modulus of elasticity X10^6, psi.	30	30	26	31	30.8	26	26	31
Electrical resist., ohms/cir.mil.ft.	57	50	290	590	812	800	350	750
Thermal exp. coeff. X10^{-6}, 32-212F., in./in./F.	7.2	7.2	7.8	6.4	5.6	6.3	7.8	7.6

Composition of Nickel Alloy Metals—Table II

	C	Mn	Fe	S	Si	Cu	Ni+Co	Al	Ti	Cr	Cb+Ta	Mo	W	P
Nickel	0.15	0.35	0.40	0.01	0.35	0.25	99.0 min.	.....	.....	.....	.....			
Low carbon Ni	0.02	0.35	0.40	0.01	0.35	0.25	99.0 min.	.....	.....	.....	.....	.....	.....	.....
Monel	0.30	2.00	2.50	0.024	0.50	Bal.	63.0–70.0	.....	.....	.....	.....	.....	.....	.....
Inconel	0.15	1.00	6.00–10.00	0.015	0.50	0.50	72.0 min.	.....	.....	14.0–17.0	.....	.....	.....	.....
Hastelloy B.....	0.05	1.00	4.00–6.00	.....	1.00	....	Bal.	.....	.....	1.00	.....	26.0–30.0	.....	.....
Hastelloy C.....	0.08	1.00	4.00–7.00	0.03	1.00	....	Bal.	.....	.....	14.5–16.5	.....	15.0–17.0	3.00–4.50	0.04
K Monel	0.25	1.50	2.00	0.01	1.00	Bal.	63.0–70.0	2.0–4.0	0.25–1.0	.....	.....	.....	.....	.....
Inconel X	0.08	1.00	5.00–9.00	0.01	0.50	0.50	70.0 min.	0.4–1.0	2.25–2.75	14.0–17.0	0.70–1.20	.....	.....	.....

dizing conditions tend to promote corrosion of nickel, this is not a general rule, particularly under conditions where a film can form. Nickel is a magnetic material.

Low-carbon nickel, containing a max. of 0.02% carbon is immune to graphite formation. This grade can be used at temperatures above 600 F. But limiting its carbon content results in lower mechanical properties. Physical properties (see Table I) and corrosion resistance are the same as the 0.15% carbon nickel.

Monels for High Temperature

Monel is a nickel-copper alloy with about 30% copper. Its tensile strength is higher than mild steel, but lower than stainless steel (Monel is about 80,000 psi., stainless 100,000 psi. at 600 F.).

Corrosion resistance is greater than nickel under reducing conditions, and greater than copper under oxidizing conditions.

In general, Monel provides a higher degree of resistance to corrosive attack compared to nickel or copper alone. This results from the formation of very stable, passive oxide films. Normally Monel is slightly magnetic.

Harder and stronger than Monel is K Monel—a nickel-copper-aluminum alloy with 30% Cu and 3% Al. It has a tensile strength of around 138,000 psi. at 700 F. compared to 76,000 for Monel. K Monel can be age hardened to develop approximately 50% greater tensile and yield strength than the unage-hardened material. Very high tensile and yield strengths can be developed in heavily cold worked and aged K Monel. Age hardening treatment only removes a small amount of this cold work. At the age-hardening temperature of 1,100 F. this alloy does not soften or over-age with time.

Corrosion resistance is about the same as Monel. Therefore its main advantage is superior high temperature performance.

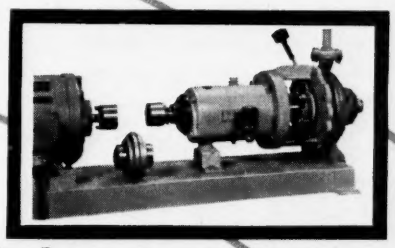
Hastelloys Are Good, Too

Hastelloy B is a nickel- molybdenum-iron metal containing about 28% Mo and 5% Fe.

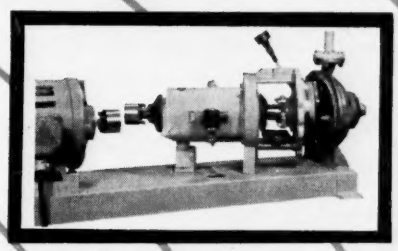
It has very good strength at elevated temperatures (116,000 psi. tensile strength at 800 F.). It is particularly recommended for boiling hydrochloric acid, wet hydrogen chloride gas, and the more aggressive concentrations of sulfuric acid. It can be age hardened, and it is nonmagnetic.

Hastelloy C contains 17% Mo, 15% Cr, 5% Fe and 5% W. It also resists low temperature embrittlement. And it has excellent strength at high temperatures (110,000 psi. at 800 F.). Hastelloy C not only shows high resistance to strong oxidizing acids, but it also resists localized attack by these acids. It also can be age hardened and is nonmagnetic. (*Continued p.* 302)

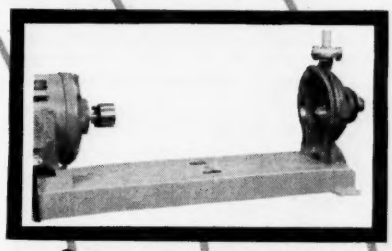
Time is money - and so is labor!



1. Remove spacer from coupling.



2. Remove cap screws.



3. Remove the pump. Note: Neither suction or discharge lines are disturbed, nor is motor or alignment affected.

3 simple steps remove SERIES H DURCOPUMPS for maintenance

Lower operating and maintenance costs with rugged, dependable, Series H Durcopumps. Simple design and sturdy construction assure long hours of trouble-free pumping. Easy, three-step, one-trade maintenance reduces down time, speeds maintenance, and lowers costs. Series H Durcopumps are available in Durimet 20, the 300 series stainless steels and in eleven other standard alloys for pumping all types of corrosive solutions. A complete range of pump sizes accommodates heads to 350 ft. and capacities to 4500 gpm. Write for details.

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Specs Which Apply to Ni and High-Ni Alloys—Table III

	Bar, Rod	Pipe, Tubing	Condenser Tubing	Plate, Sheet, Strip
Nickel	SB-160	SB-161	SB-163	SB-162
Low carbon Ni	SB-160	SB-161	SB-163	SB-162
Monel	SB-164	SB-165	SB-163	SB-127
Inconel	SB-166	SB-167	SB-163	SB-168
Hastelloy Alloy B	(a)	.....	.....	(a)
Hastelloy Alloy C	(a)	.....	.....	(a)
K Monel	Navy Mil-N-17506	.....	.....	Navy Mil-N-17506
Inconel X	AMS-5667D-5668D	.....	.....	AMS-5542D

(a) ASTM specification in process

Inconels Superior to Nickel

Inconel contains 15% Cr and 7% Fe. It's much harder and stronger than mild steel.

In some respects this alloy shows much resemblance to the austenitic stainless steels. At elevated temperatures, Inconel provides not only exceptionally high strength (90,000 tensile strength at 800 F.) but also offers high resistance to oxidizing types of corrosion.

In the temperature range of 900 to 1,400 F. no embrittling structural changes occur. The chromium content makes Inconel superior to nickel under oxidizing conditions, and the nickel content contributes to the high resistance of this alloy to corrosion under reducing conditions.

Inconel X is a nickel-chromium-iron-titanium alloy containing about 15% Cr, 7% Fe, 2.5% Ti and 0.75% Al.

It is considerably harder and stronger than Inconel (*see curves*). And its tensile and yield strengths can be increased some 50% by age hardening. Inconel X is slightly less resistant to corrosion compared to Inconel, but it holds strength better at temperatures around 1,000 to 1,600 F.

Usually a direct aging treatment (20 hrs. at 1,300 F.) is given to plate and sheet Inconel X. But in the design of pressure vessels, the placing of weld warrants must take into account the fact that welds in Inconel X have only 65 to 75% of the rupture strength of the base material. Welds, then, have to be placed in the cooler areas of the vessel, or they must be reinforced.

Embrittlement Problems

At high temperatures nickel has a great affinity for sulfur. A low-melting intergranular compound forms. At around 500F. a brittle compound, which exists in the grain boundaries, forms. At 1,200 F. the eutectic between nickel and nickel sulfide melts, and this can cause hot shortness by rupture through molten grain boundaries.

Monel, and particularly K Monel, are somewhat more resistant to this type of deterioration, although the safe maximum temperature for these materials under sulfur-containing environments is about 700 F. The presence of chromium helps in resisting embrittlement by raising the fusion temperature of the sulfide. However, application of nickel-base heat resisting alloys to sulfur environments should be done with considerable caution. Once embrittlement from any source has occurred, there are no mechanical or thermal treatments which will restore ductility. The defective area must be removed and replaced.

Possibility of embrittlement must also be considered for annealing or welding, where temperatures can go over 700 F. Prior to heating, the metals must be clean and free of any material which might contain sulfur, lead or other harmful substances. Charcoal, coke and coal always contain too much sulfur to be useful in heating these alloys. Butane, propane, natural gas or manufactured gas containing not more than 20 grains of total sulfur per 100 cu. ft. are satisfactory. Fuel oil, with less than 0.5% sulfur (Grade I) is satisfactory for heating.

Behavior in Fabrication

Differences in the work-hardening characteristics of nickel and high nickel alloys alongside those of mild steel and some other construction materials are shown on p. 304.

Cold forming of nickel and the high-nickel alloys may be accomplished on equipment of the same general type used for steel. In sulfur-free atmospheres, hot forming such as forging, pressing, spinning and bending can be performed on parts thoroughly cleaned to avoid embrittlement.

Stress-equalizing heat treatment, a low-temperature treatment given to heavily cold-worked Monel and nickel, will increase the proportional limit substantially with very little change in strength factors, ductility or microstructure. Pipe or tube, when ordered stress-equalized, is held at 535-650 F. for a period of 1 to 12 hr. This provides the hardest temper recommended for pressure vessel use.

Tubing so treated is not suitable for bending. Monel and nickel pipe is also available in the stress-relieved temper. When so treated, they are softer than stress-equalized grades, but harder and more resistant to erosion than tubing in the annealed condition. Stress-relieving has no beneficial effects on Inconel, Inconel X or Hastelloy alloys B and C.

Annealing treatment reduces the hardness of nickel, low-carbon nickel, Monel and Inconel. The higher the annealing temperature, the lower the hardness and the larger will be the final grain size. Obviously, the needed compromise between grain size and hardness determines time and temperature of the anneal. Hastelloy alloys B and C, K Monel and Inconel X can also be fully annealed at appropriate temperatures, but require rapid cooling of thin sections or quenching of heavy parts.

Age-hardening treatment is used to develop maximum properties in Inconel X for applica-

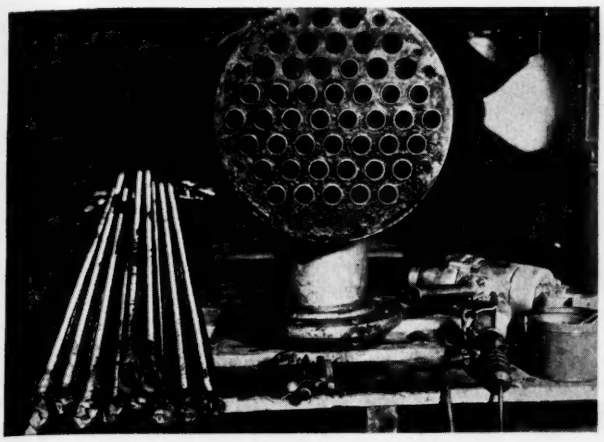
BRIDGEPORT BRASS

COPPER ALLOY BULLETIN

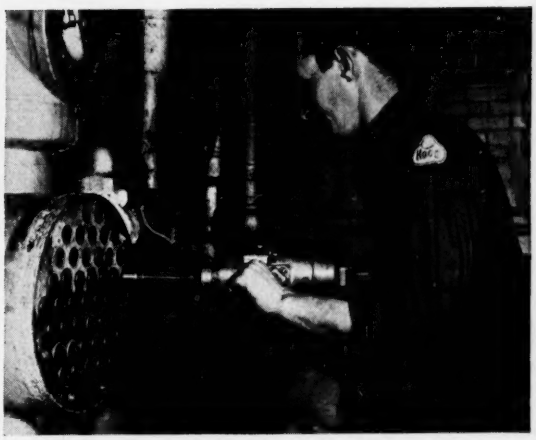
CONDENSER AND HEAT EXCHANGER TUBE EDITION

How to Equip Ammonia Condensers For Long, Low-Cost Service

New England Dairy Does It with Bridgeport Duplex Tubes



New Bridgeport Duplex Tubes being installed in ammonia condenser. On left are original steel tubes which had average service life of 7 years and had to be cleaned at least 3 times a year.



Bridgeport Duplex Tubes being rolled in to make tight, leakproof seats. Most Duplex Tubing can be expanded and rolled in as readily as single-metal tubes.

When dual corrosion problems exist, Bridgeport Duplex Tubes help cut maintenance costs and improve operating efficiency. The reason is that each alloy used in a Duplex Tube can be selected to withstand the specific corrosion problem on each side of the tube.

Operation on Ammonia Condensers

The experience of H. P. Hood & Sons, Boston, Mass., one of New England's largest dairies, is a case in point. Recently, this company installed Duplex Tubes in gas coolers and condensers in some of their plants, including their Boston ice-cream plant.

The units, cooled with city, well, and spray tower water, formerly used steel tubes, which required cleaning as often as three or four times a year. Head pressures under peak loads ran to 200 psi and over. The steel tubes averaged 7 years of effective life.

Duplex Tubes Boost Performance

The steel tubes were replaced by 1¼" OD x .089" Duplex Tubes — .042" copper inside and .047" steel outside. Life expectancy of the Duplex installation is 20 years or more, and the chief engineer anticipates no cleaning during this period. Head pressures under peak load in most cases are down to 165 psi, with proportionate water savings.

The Duplex Tubes have cut maintenance costs by eliminating cleaning operations and by giving three times longer service. Water costs have been reduced by about 10% and head pressures by 17%.

Past Experience A Factor

One reason for the Hood Company's decision to use Duplex Tubes has been its long and favorable experience with them. Direct experience goes back to 1949, indirect experience to 1938, when it was discovered that equipment in a plant acquired by Hood in New Haven had been equipped with Bridgeport Duplex Tubes in that year. The 1949 installation was in a plant in Portland, Maine, in a shell and tube ammonia gas cooler. These tubes have not been cleaned since put in. They have been checked at least once a year and show no signs of corrosion or erosion at the tube ends.

In the New Haven plant, Duplex Tubes, in operation since 1938, showed on inspection that they still had many years of service left. As far as could be determined, these tubes had never been cleaned.

Duplex Has Many Applications

Duplex Tubes are the efficient, economical answer to many problems in ammonia refrigeration systems as well as in ammonia and synthetic rubber production, process industries, chemical plants, coke by-products plants and oil refining. The savings they bring in longer service life and less frequent retubing and shutdowns quickly repay their original cost.

Help In Selecting Duplex

Our long experience in the field can save you time in selecting the right Duplex combination—in metals and gauge—for your specific conditions. Call your nearest Bridgeport office today.

Send for these Duplex and Condenser Tube Bulletins

Technical Bulletin #1954 is a 16-page brochure giving properties, applications, and other important Duplex Tube information.

The Bridgeport Condenser Tube Handbook is a comprehensive 162-page manual covering all phases of heat-exchanger and condenser-tube design, operation and application.

Copies sent on request. (2425)

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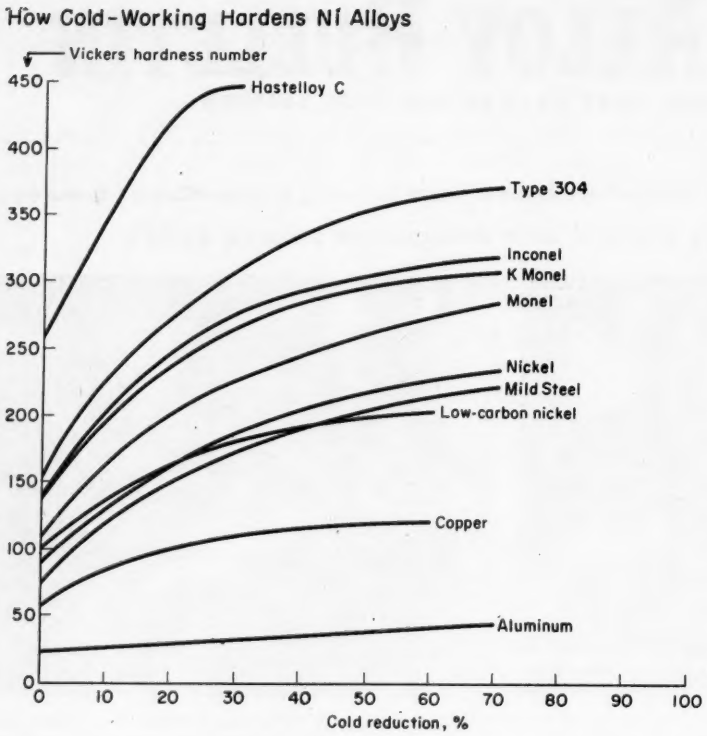


tions at temperatures up to 1,100 F. It fully hardens the alloy if held for 20 hr. at 1,300 F. K Monel develops full properties if it is held for 16 hr. at 1,080-1,100 F, then cooled in the furnace at 15 to 25 F./hr. to 900 F. For most applications, sufficient hardening results from holding it at 1,100 F for 6 to 8 hr.

Machining of high nickel alloys is not difficult, but different than usual shop practice. Despite inherently superior strength and toughness (as well as faster work hardening response and greater hardness than mild steel) good machining results will follow use of the correct combination of tooling, cutting compound, speed and feed for each alloy.

The machinist requires tools made from high speed steels—cast nonferrous or cemented carbides—because the task calls for high hardness at red heat. Maintenance of sharp and properly ground cutting edges is also required. Cutting oil must be amply flooded on the work, and a continuous cut taken while avoiding excessive speeds and feeds.

Welding Processes

Welding processes normally employed in steel pressure vessel fabrication can, with certain modifications, be used for joining nickel and high-nickel alloys. Generally there is no need to preheat. Single phase alloys usually need no stress relief after welding, but the age-hardenable alloys do. They require it to prevent cracking during aging, and they need heat treating to develop maximum properties. As a rule, molten alloy weld metal is less fluid, and correspondingly less penetrative, than steel weld metal. Accordingly, joint preparation demands ample opening up to allow placement and manipulation of the deposited weld metal. And in all welding, cleanliness is vitally important to avoid embrittlement.

Shielded metal-arc welding with coated electrodes remains by far the most popular method for joining material from ⅛-in. up. It is essential to remove all trace of flux; especially from equipment for elevated temperature operation, because molten flux residue attacks the base metal. Even at normal temperature it may form focal points for the start of corrosion, or contaminate products handled by the vessel.

Inert-gas metal-arc welding, also known as the heliarc, heliweld or inert arc process, has gained favor because, generally, it needs no flux. For this reason alone, it is often specified where traces might jeopardize product purity.

The inert-gas metal-arc method known as aircomatic, sigma or filler arc process, finds increasing use on heavy gages, because it permits high deposition rates and also eliminates flux removal problems.

Oxyacetylene offers advantages, as well as disadvantages. Its slower rate proves a benefit in welding thin gages, especially tubular joints. Brazing also has application, but its use is rare. High-nickel alloys are occasionally joined with other processes, but those described above prove most satisfactory in pressure vessel work. Joining high-nickel alloys to each other or to other ferrous or nonferrous metals is commonplace, and the preferred process is, of course, the one that minimizes dilution.

Pressure vessels as large as 14-ft. in length by 7-ft. in dia. have been produced in the age-hardening alloys. But in each instance size allowed final heat treating in a furnace, and no field welding was required. Fabricating difficulties prohibit use of age-hardenable alloys for heavy structures that are too large for heat treating.

Cleaning Processes

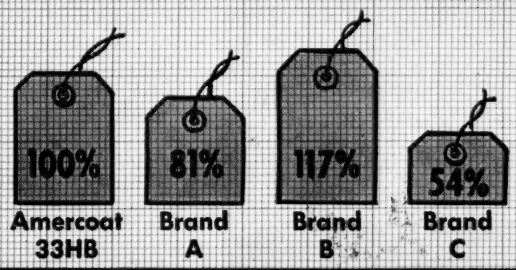
For removal of oils or greases, conventional cleaning techniques—caustic degreasing, vapor or solvent wash—are used on nickel and nickel alloys, as on steel.

For oxide removal, acid pickling methods are useful, although there is the danger of overpickling. The fused salt descaling method is much preferred for nickel alloys. Such salts as sodium hydride readily reduce the oxides, and produce a reduced oxide which can be removed with a short pickle.

Procedure for inspecting high nickel alloy units parallels that used for steel pressure vessels, and includes hydrostatic and

YOU CAN'T KNOW
what the real price tag is...

How price per gallon compares on leading vinyls



UNLESS YOU
compare mil sq. ft. per gallon and...

Sq. ft. coverage per gallon, 1 mil thick

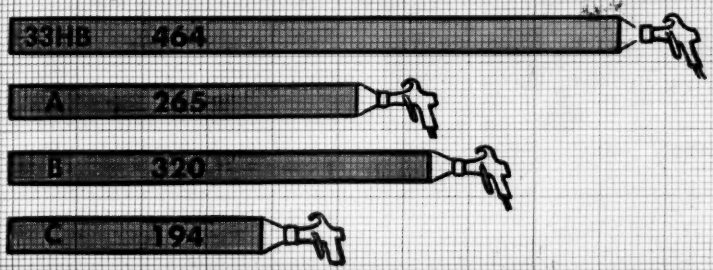
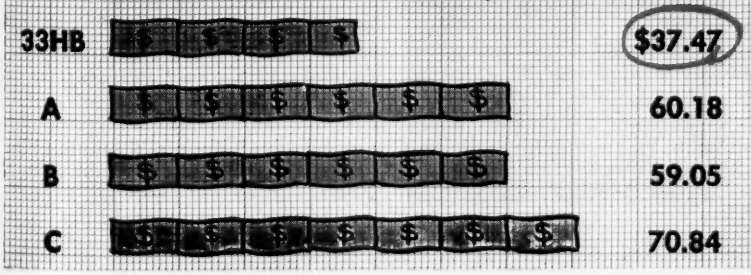


FIGURE THE
material cost of each coating, then get the...

		GALS.	COST
Needed to coat 250 sq. ft. 5 mils thick	33HB	2.68	$17.37
	A	4.72	24.78
	B	3.91	29.72
	C	6.44	22.54

REAL COST
by adding labor for the number of coats needed.

Labor & material cost, 250 sq. ft. x 5 mils thick



Announcing...

A True High Build Vinyl Coating

Amercoat 33HB now gives you even *more* "mils per gallon" —and at the lowest cost of any leading vinyl!

At last, the two major limitations of vinyl protective coatings—critical adhesion and low film thickness—have been largely overcome. Amercoat 86 Primer stopped adhesion troubles, eliminated underfilm corrosion and undercutting, and simplified surface preparation. *Now Amercoat 33HB Topcoat builds thick films in fewer coats at surprising savings.*

Amercoat 33HB is a "high-build" version of Amercoat 33, the standard of the protective coatings industry for over ten years. 33HB gives you the same high resistance to corrosive chemicals, severe weathering and abrasion, *plus 33% greater thickness per coat!*

The solids content of 33HB tops all other non-mastic vinyl coatings, yet workable viscosity is retained. It applies smoothly and easily by hot or cold spray. No need to stock two types of materials.

New Lower Cost

In evaluating any coating, always look at the cost per square foot, and the number of coats required to build proper film thickness. 33HB is nearly 24% cheaper per mil square foot than traditionally low cost 33...and compared to other leading vinyls, (see chart) savings are even greater. For example, although the gallon price of Coating "C" is 46% lower than 33HB, because of its low solids content the actual *material* cost for 5 mils thickness is almost 30% higher than 33HB, and the applied cost, (labor and material) is almost 90% higher.

For the full story, send coupon for data on 33HB and detailed cost comparison of the four coatings on the chart.

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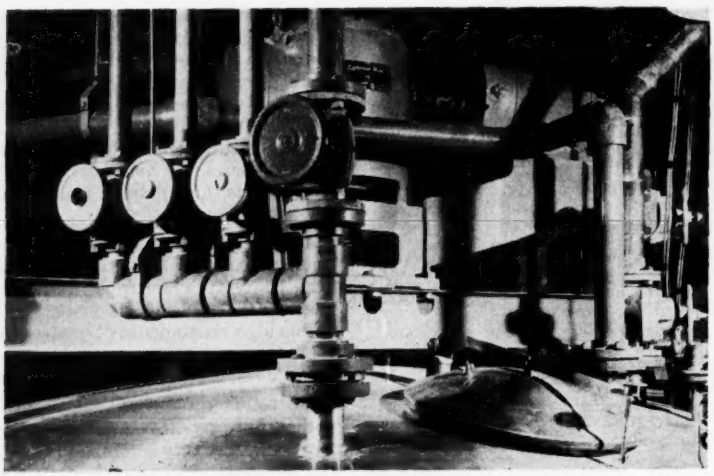
radiographic tests. Points that warrant particular scrutiny include cleanliness, slag removal, crevices, weld smoothness and the like, because they influence corrosion resistance and thus affect life of the vessel.

Experience shows that the combination of strength, toughness and other desirable properties, along with inherent resistance to corrosive attack, makes nickel and high-nickel alloys especially suited for pressure vessels where operating conditions are severe.



Hard Look at Plastic Pipe

It's cheap but can't take temperatures over 140 F. Here are pros and cons on the use of plastic pipe.

Over $55 million worth of plastic pipe was purchased in the U. S. in 1956. Estimates are that this will be doubled by 1961.

Much of this pipe will be used outside the chemical industry. Nevertheless, plastic pipe when properly selected, fabricated, and installed can be very important to the U. S. chemical industry. Engineers should be aware of the advantages and shortcomings.

By far, the most important is thermoplastic pipe:

• Cellulose acetate butyrate. The CA butyrate pipe is not recommended for corrosive solutions, since it has a saponifiable ester. It is suitable for water.

• Saran. Actually Saran has a longer history of successful use than any other thermoplastic pipe. It contains a small amount of plasticizer and thus tends to become embrittled after many years of use. It has been used to line steel pipe.

• Styrene-rubber blends. Pipe made from blends of copolymers of styrene with acrylonitrile, and butadiene with acrylonitrile, is resistant to many types of corrosive chemicals.

• Polyethylene. Low-density polyethylene lacks rigidity, but the newer high-density polyethylene pipe is rigid and hard. This material is not effected adversely by most aqueous corrosive solutions. At least 75% of all plastic pipe produced today is based on polyethylene.

• Rigid polyvinyl chloride. The rigid vinyl pipe is extruded without plasticizer, and has been produced in this country since 1948. Two types are available: Type I for normal impact, and Type II for high impact.

Other types of pipe used in the U. S. include: polymethylmethacrylate, which has limited use but is transparent; nylon, which shows promise in hot water service; chlorinated polyether, which is in the pilot plant stage, but shows excellent heat and chemical resistance; polyfluorocarbon pipe and tubing, which is expensive, but has excellent resistance to heat and corrosives.

Most plastic pipe lacks resistance to organic solvents, but good resistance to corrosive aqueous solutions. Interiors are smooth, and little deposit buildup takes place. Thus it is often possible to use smaller pipe diameters.

It is relatively cheap to produce. But plastic pipe lacks resistance to high internal pressures, and it has a high coefficient of expansion. It is generally not satisfactory for temperatures above 140 F. and is subject to cold flow.

Based on a paper presented at the 13th Annual Conference, National Association of Corrosion Engineers, St. Louis, Mo., 1957, by R. B. Seymour, Loven Chemical of Calif.

Next Month: How to Handle Corrosion Data

Probably you've had the experience of trying to look up corrosion data in your company file, and checking every category but the correct one. Next month Corrosion Forum will show you how an alert chemical company—American Potash & Chemical—solved this problem with punched cards.

Chemical Engineering

People

MAY 1957

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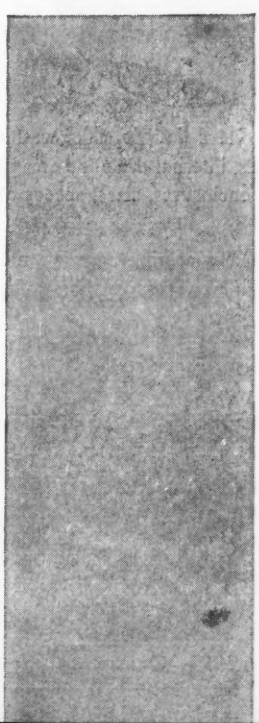

Do you earn as much as other engineers? **313**

These charts, released by the Engineers Joint Council, show how much engineers earned in 1956. What about you? In comparison how does your take-home pay rate?

Technical Bookshelf **320**

Still more on electrochemistry . . . a volume designed to give you a brief coverage of chemical kinetics . . . a large selection of papers on biological treatment of sewage.

Meet Your Authors **326**

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Lion Oil Co. onstreams a Canadian oil facility . . . Sylvania-Corning Nuclear Corp. has been formed . . . Olin-Mathieson readies a new line of nonionic surface-active agents.

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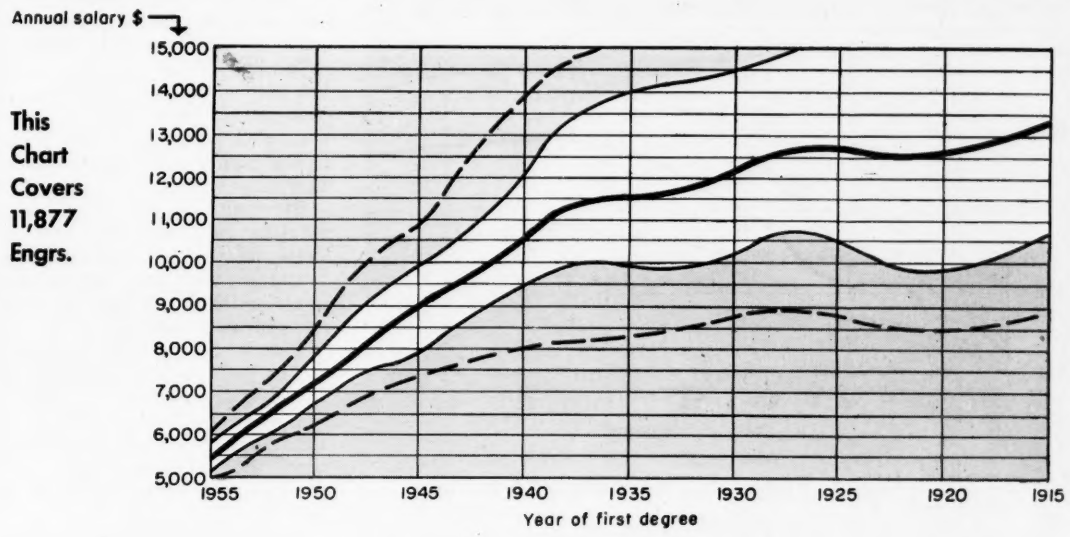
Annual Earnings of Engineers in Chemical and Allied Industries

Year of First Degree	1955	1950	1945-46	1940-44	1935-39	1930-34	1925-29	1920-24
Highest	8,500	12,500	13,500	15,000+	15,000+	15,000+	15,000+	15,000+
Upper decile	6,125	8,550	10,650	12,750	15,000+	15,000+	15,000+	15,000+
Upper quartile	5,850	7,825	9,750	11,150	13,650	14,375	15,000+	15,000+
Median	5,525	7,250	8,800	9,900	11,550	11,750	12,775	12,600
Lower quartile	5,275	6,750	7,875	8,900	10,125	9,925	10,825	9,925
Lower decile	5,075	6,350	7,250	7,900	8,350	8,575	9,075	8,550
Lowest	4,250	4,625	4,750	4,750	4,750	5,500	5,175	6,075



How Does Your Salary Stack Up, Now?

Data on the 1956 income of 107,832 engineers have just been released by Engineers Joint Council. How did you rank in 1956? What about 1957?

Your salary progression is an unsteady-state rate process. As with other unsteady-state processes in chemical engineering, our best analytical approach is to isolate instantaneous profiles along the rate curves.

If we can obtain a sufficient number of instantaneous profiles, then we can project the probable future path of the variables.

Undoubtedly your salary is a much more personal thing to you than a problem that can be analyzed in these cold engineering terms. As individuals we like to make our own appraisals of the engineering salary situation and decide whether it's good or bad.

However, for us to exercise our individual engineering judgments, we must have reliable data to work with. We now have such data up to the end of the year 1956.

Here's a Reliable Benchmark

Just recently the Engineers Joint Council released its special report* on the professional in-

* Report No. 102, "Professional Income of Engineers—1956," available from Engineers Joint Council, 29 West 39th St., New York 18, N. Y., at $1.50 per copy.

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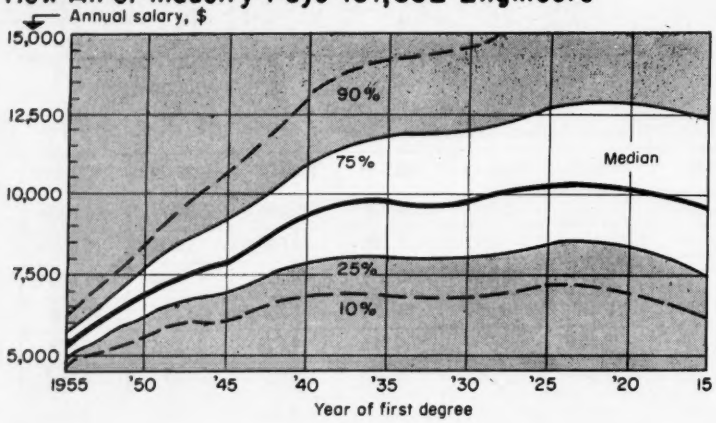
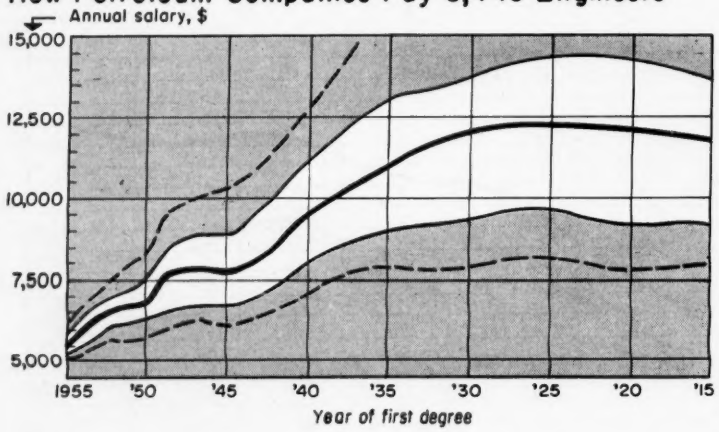
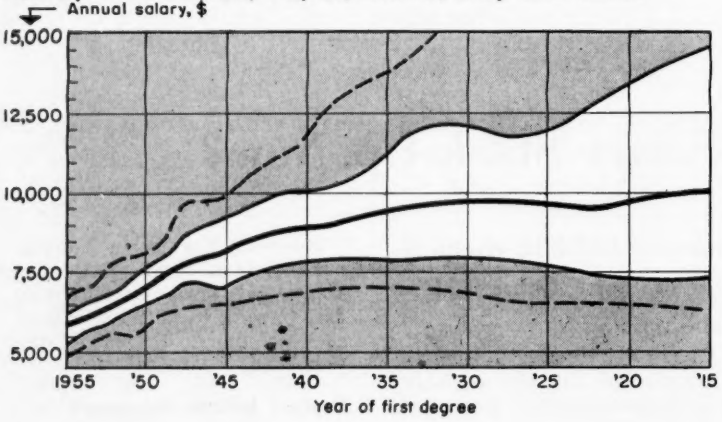
How All of Industry Pays 107,832 Engineers



How Petroleum Companies Pay 6,449 Engineers



For 2,776 in Wood, Paper, Stone, Clay and Glass



come of engineers for last year. This report establishes a reliable benchmark for the administration of engineering salaries.

The first chart summarizes the findings for engineers in the chemical and allied products manufacturing industry. Most of you reading this are in this classification.

You'll want to compare how you stand vs. other engineers. Therefore, we've reproduced also the findings for all engineers; those who manufacture crude petroleum, natural gas, and the products of petroleum and coal; and a final chart that includes engineers in the textile, lumber, wood, paper, stone, glass and clay products industries.

How to Read the Charts

In the interest of uniformity of understanding when these charts are put to work, EJC has provided the following definitions:

Earnings—Base salary including any cost-of-living allowance, if any, and bonus if considered part of salary, but not including payments for overtime work.

Income—Total income from the practice of engineering. As used in this sense, this information was obtained from those in the field of engineering education only.

Starting Salary—The base starting rate, including cost-of-living allowance for engineering graduates with baccalaureate degrees without military or other compensable experience.

Year of Entry Into Profession—The year in which the baccalaureate degree was awarded.

Engineer—The holder of a minimum of a B.S. in a recognized field of specialization regardless of current position or activity.

On the summary charts you'll find five lines of separation. They are the median; upper quartile and decile; lower quartile and decile. And they are defined as follows:

Median—The point in any array of data above and below which half of the series is located. The value of the median is that it can be computed immediately even when the series contains open-end class intervals such as "under $3,000" and "$15,000 and over" as used in this survey. However, all figures are rounded out to the nearest $25 unit.

Upper Quartile—The point in any array of data above which 25% of the series is located.

Upper Decile—The point in any array of data above which 10% of the series is located.

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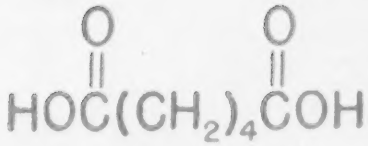

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What Employers Offered New Graduates in 1956

Employer	Reported Monthly Salary, $ Highest	Lowest	Median
Chemicals and allied products	450	375	410
Machinery, except electrical	450	350	410
Electrical machinery	500	375	425
Transportation equipment	500	350	425
Instruments	465	390	410
Railroads	425	365	410
Telecommunication services	425	300	390
Public utilities	435	325	400
Miscellaneous services	500	300	425
R & D services	500	360	425
Federal government	410	250	375
Government, not federal	435	250	375
Crude petroleum, products of petroleum, coal, gas	450	390	435
Metal mining, primary metals and fabricated metal products	490	375	405
Nonmetallic mining, building, food, textile, wood, paper, stone, clay and glass products	465	350	415

Lower Quartile—The point in any array of data above which 75% of the series is located.

Lower Decile—The point in any array of data above which 90% of the series is located.

Although we have not reprinted them here, you will find tabular data for these summary curves in the EJC report.

Only an Instant in Time

However, the most important definition has been left unsaid. You should remember that these charts record only a single point in time: the year 1956.

We have been given a very reliable profile of a single instant in a rate process. Yet caution should be exercised in extrapolating the results of this survey to any other point in time. Engineers change. Samples are never alike. Starting salaries have been on an upward binge for several years, now. Fringe benefits cloud comparisons. And the cost of living never seems to level off.

For their survey, EJC mailed questionnaire forms last summer and accepted replies until December 1. Thus, the survey began obsolescing before it was compiled. As college students met recruiters in the fall, it seemed apparent that 1957 starting salaries would certainly top the high levels of June 1956.

With the start of 1957 and the approval of 1957 budgets, many companies granted periodic merit as well as promotional increases to their engineers.

Cost of living is still headed upward. The average cost of living index in large cities (as reported by the U. S. Dept. of Labor) stood at 116.2 in June of 1956; rose to 118.2 in January of this year—a two-point jump in only seven months.

Some engineering salaries are tied to this index. Therefore, the charts should be adjusted for this variable before we try to use them for any year except 1956.

Adjust With Caution

Yes, the charts should be adjusted for variables that depend on time. But how exactly should we make these adjustments?

This is where your individual engineering judgment must be applied. We'd like to cite just one sample problem. In the table above we have listed the starting monthly salary base rates as reported by EJC for June 1956 graduates.

Assume that 1957 offers to new graduates are $25 per month higher than they were last year. Does that mean that every other engineering salary will be increased $25 per month? Should all the curves be shifted upward by translation of the vertical axis?

It most certainly doesn't. And in the terminology that is often used in engineering textbooks, the solution of this problem is left to the reader—and to his employer.

What About Management?

You may have decided, after studying the accompanying charts, that the curves are too low, that they don't present a true picture of all engineers including managers.

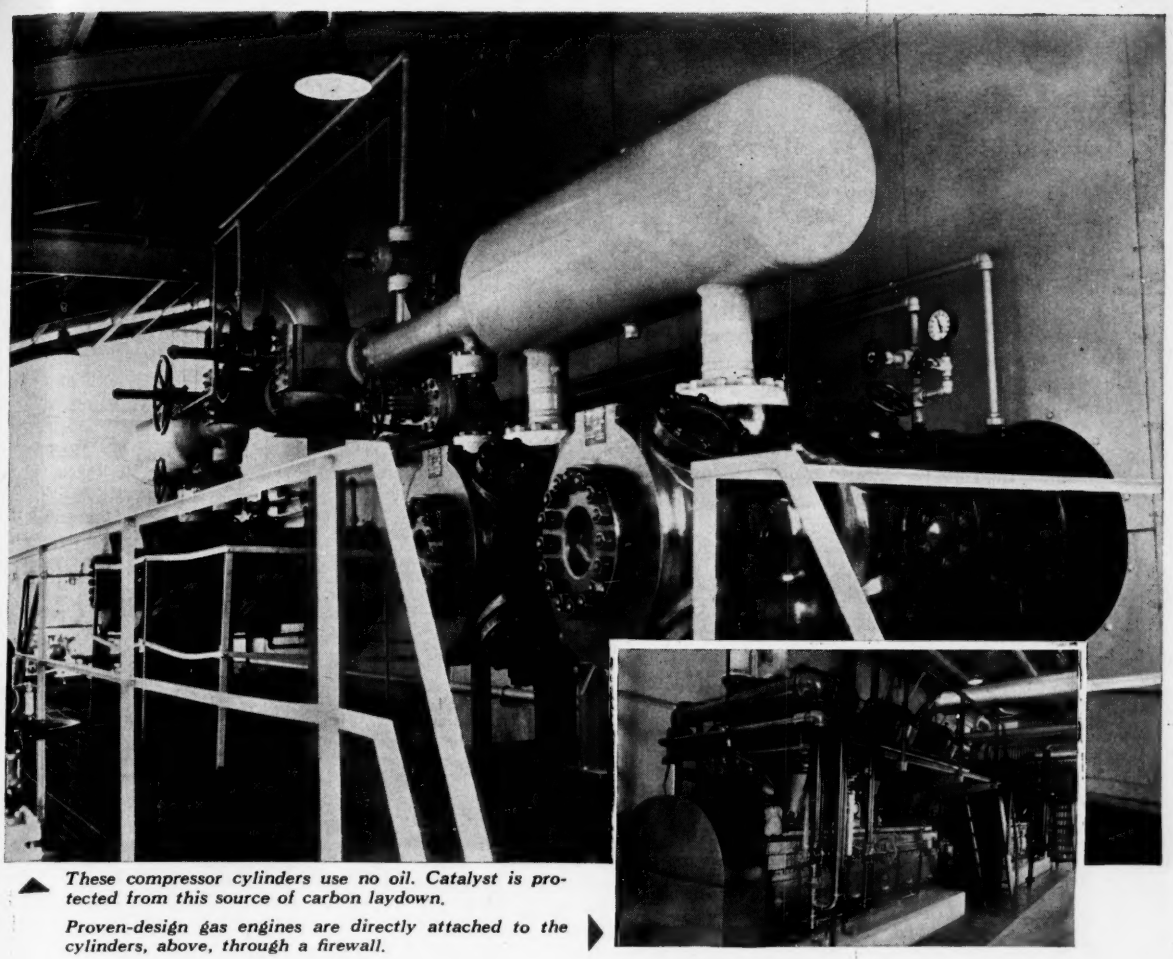
EJC was concerned about this same question. Contributors were asked to supply data on all engineering graduates, including those in supervisory as well as nonsupervisory capacities. In general the data reflect the earning status of all engineers but EJC's analysis of the returns indicated that the survey was not completely successful in this regard. Quoting from the report:

"It is felt that top administrative and managerial salaries are not fully represented and therefore the salary presentation is lower than the true structure, particularly for classes earlier than 1935. Nonetheless, the committee feels that the data closely approximate the earning position of the engineers employed by the contributing companies."

When we read through this report, we were impressed with the method used to obtain accurate information. Companies were asked to scour their payroll records to find people who had engineering degrees, regardless of their position in the company. This is certainly a better route to reliability than questioning individual engineers about their earnings.

But how high up the company ladders did the payroll records go? We'd like to raise a single supposition to explain our puzzlement. The president of one of our largest chemical companies was graduated from Cornell University in 1920 with a degree in mechanical engineering. His basic compensation in 1955 (1956 figure not available) was $262,500.

If you were the personnel relations manager for this company, would you include this figure in your completed ques-



These compressor cylinders use no oil. Catalyst is protected from this source of carbon laydown.

Proven-design gas engines are directly attached to the cylinders, above, through a firewall.

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tionnaire? Perhaps you would. Maybe you would not.

What About Chemical Engineers?

You may have asked in reading this, "What about chemical engineers? How do they make out in comparison with other engineers?"

With what we think is sound reasoning the EJC survey made no attempt to obtain salary information by basic field of specialization. EJC is of the opinion that information by industry of employment is far more significant. We are inclined to agree.

You will be interested to note, however, that the chemical employer seems to pay his engineers along higher rate curves than all engineering employers, in general; and along higher curves than petroleum and other process-industry employers, to be more specific. (See the four charts presented above.)

Operation Bootstrap

Can we compare the EJC survey of 1956 professional income with other surveys that have been made on engineering income?

No. There are too many variables for a direct comparison. For example, the AIChE survey of 1953 was made on a very select group of engineers: those who were members of AIChE. The ACS survey of 1955 was also made on a rather select sample: members of ACS.

It would only be statistically correct to compare the first EJC survey made in 1953 with this one for 1956, with the one that will be made in 1959, etc.

Ideally, what we really need for accurate comparisons is the salary history of Mr. Joe Typical Engineer year-by-year. We're afraid that this is a statistical impossibility. There is no average engineer, and there are too many time-dependent variables that must be corrected for in some fashion.

However, every salary survey helps in "operation bootstrap." Many employers gear their wage and salary administration policies to the latest available information on what the industry is paying on the average in the community.

This means that as this 1956 EJC survey is circulated, those employers who are paying below the average will—or should—begin to raise salaries. Carrying these reactions to their logical conclusions, the 1956 survey will key a general "lifting by the bootstraps" for all engineering salaries.

By the time EJC sends out questionnaires for the 1959 survey—barring war and hydrogen bombs—most engineering salaries will have increased.

Does Engineering Pay?

That leaves us with a final unanswered question after reading through the results of this survey. Does chemical engineering pay?

This is a matter of individual engineering judgment. You have before you the most reliable data that have been amassed up to now on this subject.

What is *your* answer?

ENGINEER UNION
. . . *Makes Novel Bid*

Seattle Professional Engineering Employees Assn. (Engineers & Scientists of America) has proposed a novel salary demand to the Boeing Airplane Co. whereby the blanket salary increase for engineers it represents would be established by the free market price for beginning engineers.

This plan would automatically increase the salaries of all Boeing engineers by the same percent that beginning engineers' salaries had increased during the last year.

Novel feature of this proposal is that the association's members will be asked to approve the contract without knowing the amount of the blanket increase. The contract would become effective in May but the change in beginning engineers' salaries would not be evaluated until August after the 1957 graduates had been hired. Any resulting increase would be retroactive to May 3, 1957.

On another front E&SA is losing ground. The Federation of Honeywell Engineers, an independent loosely affiliated with E&SA, voted to affiliate with the United Automobile Workers.

But only hours after the union voted, a campaign got under way to decertify the Federation as bargaining agent for 2,000 professional and technical employees at Minneapolis-Honeywell.

The auto union is counting on the Honeywell union as the spearhead of its new drive to organize engineers and scientists into its Aircraft & Avionics Engineering Council.

CAN WE REDUCE
. . . *Engineer Turnover?*

The hue and cry over the shortage of engineers has obscured the fact that engineers are changing jobs at an increasing rate.

Industrial Relations News, reports that last year, for example, 15% of the engineers in the aircraft industry quit their jobs to take new ones.

Engineer turnover has shown a steady upward trend since 1953. According to the most recent comprehensive survey, turnover was over 8% in electrical and nonelectrical machinery, research, development and consulting; over 10% in professional and scientific instruments; and nearly 13% in transportation equipment.

Next Month: How Easily Can You Be Replaced?

Consider what would happen if your employer tried to find a replacement for you in the open market. Would he have an easy time of it or would he suddenly realize that you are more valuable to him than he thought? Next month You & Your Job tackles part of this question by analyzing both the quantity and quality of some of your competitors. How many newcomers enter the profession each year? What's the long-range trend? What quality is your competition?

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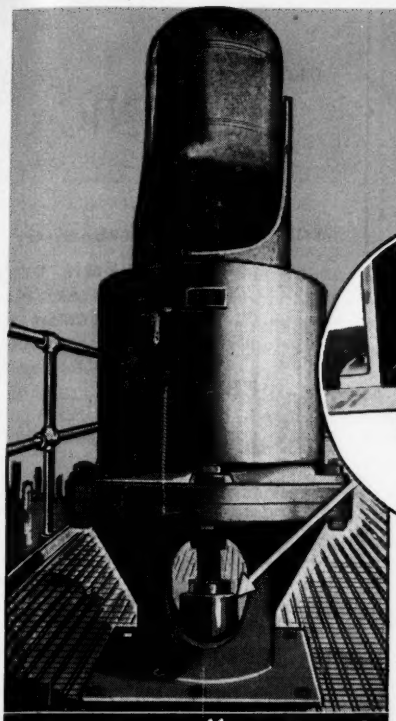

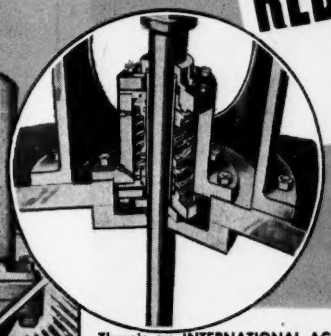

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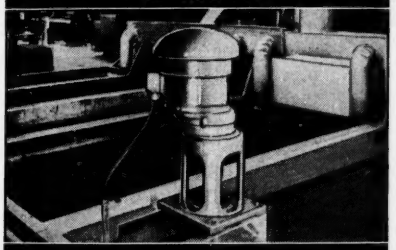

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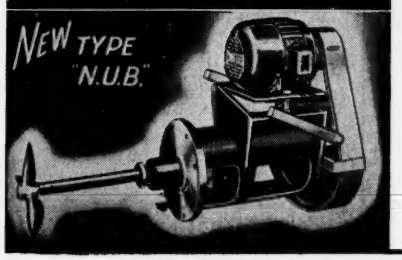

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Mixing & Extruding Machinery	62-A
Dry Blenders & Ribbon Mixers	78
Grinding & Mulling Pans	5
Ball & Pebble Mills	100-A, 100-B
Laboratory & Pilot Plant Equipment	77-A
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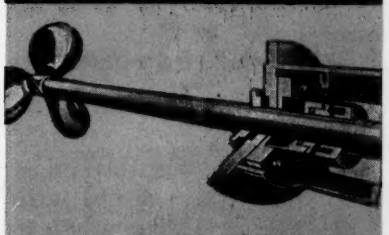

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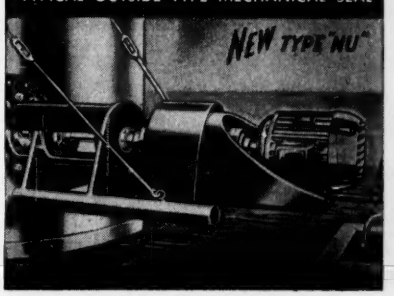

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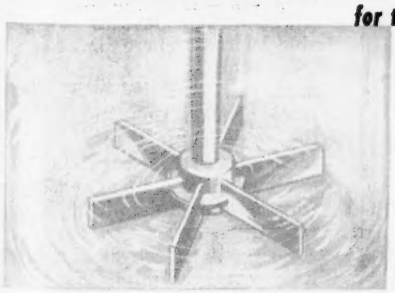

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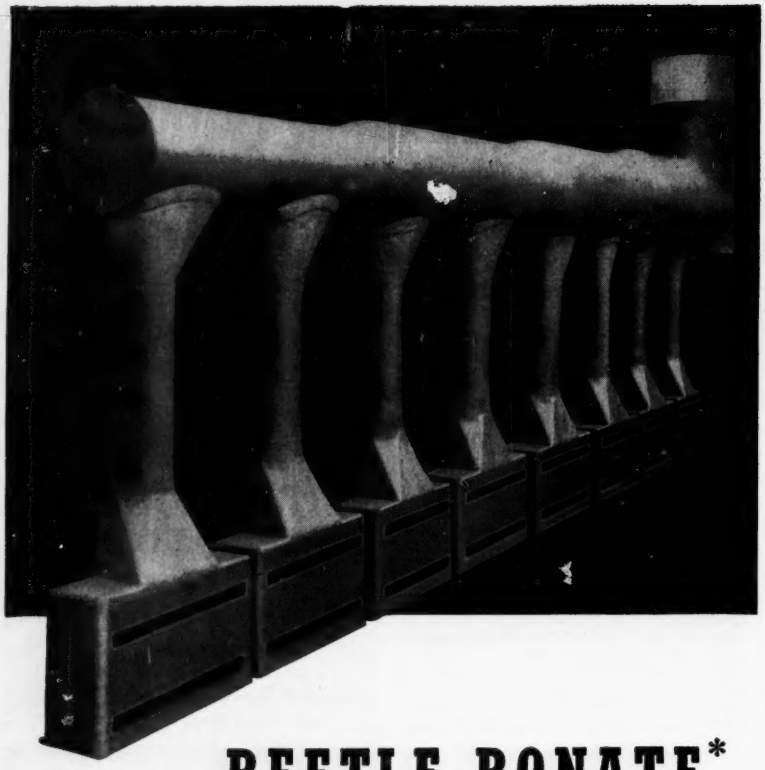

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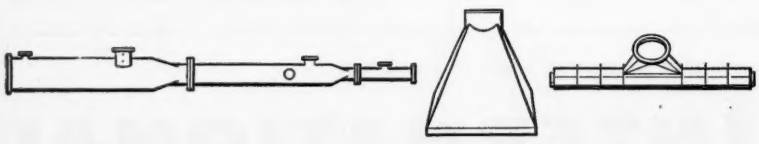

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PEOPLE . . .

TECHNICAL

Still More Electrochemistry

ELECTROCHEMISTRY—PRINCIPLES AND APPLICATIONS. By Edmund C. Potter. Macmillan Co., New York. 418 pages. $10.

Reviewed by C. L. Mantell.

In this volume, electrochemistry is defined "broadly speaking, as the study of the chemical effects of electricity. The main manifestation of electrochemistry is the phenomenon of electrolysis, which takes place when a chemical reaction proceeds under the direct influence of an electric current."

With this premise, the author discusses laws of electrolysis, conductance, ionic equilibrium, electrode potentials, reference electrodes, irreversible electrode processes, electrokinetic phenomena, electrochemical measurements in approximately 230 pages; metallic corrosion in 46 more; and general principles of technical electrolytic processes in 82 pages, with two final chapters of 50 pages devoted to primary and secondary cells.

Chapters II and III on electrolytic conductance and ionic equilibria are the standard sections from physical chemistry texts and devoted to dilute solutions—something the electrochemical engineer never meets in practice, since he's always concerned with much more concentrated solutions.

In the section on cell and electrode potentials, we might have expected that the volt would be defined, but neither the old standards nor the new ones since 1948 are mentioned.

The author devotes considerable space to corrosion, but the treatment is weak when compared to sections of International Nickel Co. literature on the same subject in about the same space. It is surprising that one has to read to page 279 before he finds a definition of current efficiency.

Sections on technical electrolytic processes might have been

BOOKSHELF

J. B. BACON

included inadvertently. In the preface the author says: "I have concentrated on the illustration of the principles and on the way these relate to the diverse applications of electrochemistry, in the belief that this is preferable to producing a precariously balanced catalogue of technical practices and theoretical ideas."

The definition of energy efficiency as the amount of electrical energy consumed in the production of unit quantity of the final recovered products appears to be a strange way of stating an efficiency. One also wonders about the figure of 1.5 kwh/lb. for zinc refining (unknown to the reviewer).

Discussion of technical processes is primarily qualitative and is similar to that found in most industrial chemistry books, but not on the level even of Shreve's "Chemical Process Industries."

The volume is just another book on electrochemistry.

History Updated

DISCOVERY OF THE ELEMENTS. By M. E. Weeks. Sixth edition, edited by H. M. Leicester. Journal of Chemical Education, Easton, Pa. 910 pages. $10.

Twelve years ago—one month before Hiroshima—we wrote on these pages as follows:

"Today we accept without much thought the idea that all matter is composed of ninety-odd elements. But man's thinking had to travel a long road with many obstacles, false starts and wide detours to arrive at this simple idea. The elements, to those ancients who first started theorizing about such things were: earth, air, water and fire. Change from the idea that water is not, but that gold is an element, from the 4 to the 92 (or more) element theory, represents centuries of time and the labor of hundreds of men.

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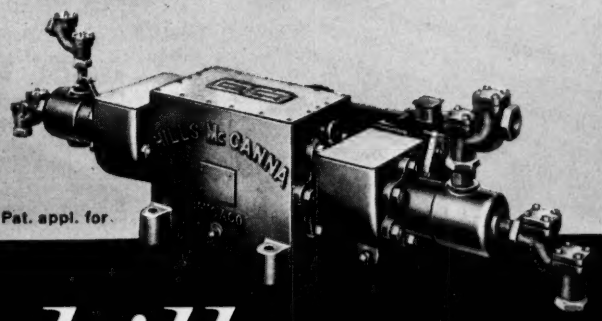

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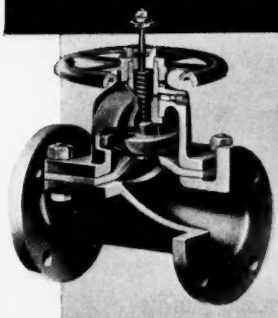

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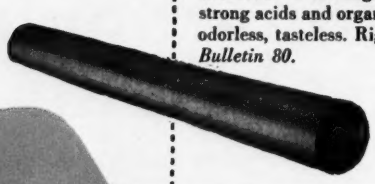

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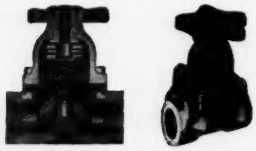

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labors that made the history which author Weeks has researched out to tell. Some of the stories (phosphorus, for example) are more interesting than others. Some are more or less familiar (radium). But all are worth reading for the background information they can give us regarding some of our great predecessors and their work."

All of this comment is still applicable to the sixth edition. But what of elements 93-101?

Today we have much of the story of progress during the years 1940-1955. It's in a new concluding chapter to "Discovery" by Dr. Leicester.—LBP

Reactor Design

CHEMICAL ENGINEERING KINETICS. By J. M. Smith. McGraw-Hill Book Co., New York. 402 pages. $8.

Reviewed by John W. Churchill

This book presents a brief and elementary coverage of basic chemical kinetics and a review of the thermodynamics necessary to evaluate equilibria involved in reversible reactions.

Objective of the book is to show how kinetic data may be correlated and applied in the design of reactors. This objective is attained effectively by mathematical derivations and complete solutions of examples. There are 56 worked-out examples to illustrate applications of these principles.

Design procedures are approached with an introductory chapter, which presents a classification of reactors as to mode of operation—batch, semibatch and flow systems.

The next three chapters are devoted to specific design methods for various classes of reactors.

It is unfortunate that in these chapters, emphasis is placed on the application of integrated rate expressions. This may give the impression that mechanisms or order of the reaction must be known for design applications. Mention should be made of the use of conversion-time curves or conversion-reciprocal-space-

velocity curves for design. Such plots and their use in selecting from assured rate expressions are given. The latter may give insight as to the nature of the reaction, but is not necessary for reactor design.

More complex kinetics involving catalysis, adsorption, desorption and heat and mass transfer are reserved to later chapters. In these chapters, the better-known principles of physical processes of chemical engineering are clearly applied. The concepts of HRU and HCU are defined and their application illustrated by evamples.

Chapter 3 and Section A of the Appendix discuss absolute rate theory. I see no harm in acquainting readers with this approach to understanding chemical kinetics. However, its usefulness in chemical engineering and reactor design is questionable.

I recommend the book to all students of chemical engineering and others working in this field. There is no question that it will effect a better understanding of reactor design involving chemical kinetics.

A Better Catch-all

BIOLOGICAL TREATMENT OF SEWAGE AND INDUSTRIAL WASTES. Vol. 1, Aerobic Oxidation. Edited by Brother Joseph McCabe and W. W. Eckenfelder, Jr. Reinhold Publishing Corp., New York. 393 pages. $10.

Compiling papers presented at a meeting in their original form under a hard cover doesn't make a book—at least not in the sense of a volume written specifically for publication in a unified form. Even the tightest editing is not likely to give the former the coordination or the impact of the latter.

So don't expect too much of this book—one which carries the proceedings (33 papers in all) of a conference on aerobic waste treatment sponsored by Manhatton College in April 1955.

As a catch-all volume, though, it is better than many. You can sense, as you look the book over, that a good deal of thought went

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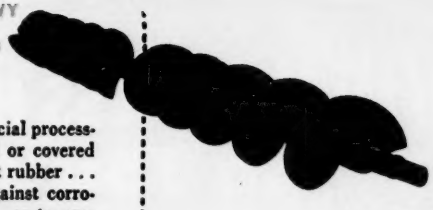

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to organizing the conference to give as complete and as smooth a discussion of the subject as practicable — with minimum overlapping in the scopes of individual contributions.

And we commend the men behind the conference and the book for bringing practical design and operating data into the open. Much of the information of this volume is simply not available in book form anywhere else.

For bio-oxidation of wastes has too long been the private domain of the sanitary engineer. Much, even, of municipal waste disposal has been hit-or-miss, with incomplete understanding of the biological processes and, what is worst of all, little assurance that results justified the cost.

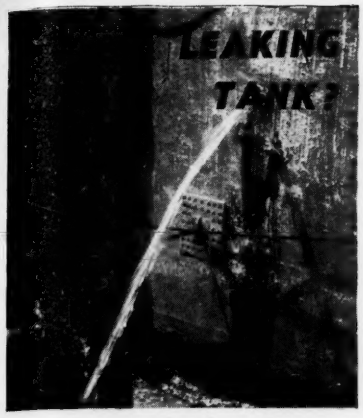
Biggest trouble with this book is that there are perhaps eight papers—generalizations, repetitions, or narrow case histories—which would hardly have been missed at the conference and could have been omitted from the compilation. Several other articles are marginal. Too bad the editors didn't trim some of the fat and label their results "selected papers."

Too many of the papers have inadequate or nonexistent discussions of results, conclusions, etc. These the editors might have contributed—with dividends to the reader.

All this makes $10 seem a stiff tab for a 393-page book that could have been condensed with profit. But it may well be worth the price. Because some of the papers are excellent: "Equilibria and Kinetics of Adsorption by Actuated Sludge"; "Adsorption of Oxygen in Bubble Aeration"; "Evaluation and Design of Biological Treatment of Pharmaceutical Wastes"; and one on the application of high-rate biofilters to sewage treatment which has a lot to offer to the industrial waste processor.—DRC

BRIEFLY NOTED

ANALOG COMPUTERS—THEIR INDUSTRIAL APPLICATIONS. *Proceedings of a symposium for management, Apr.* 10-11, 1956. 210 *pp.* $5. *Midwest Research Institute,* 425 *Volker Blvd.,*



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Kansas City 10, *Mo.* Discusses applications of analog computers to industrial control, chemical engineering process control and economics and operations research.

GLOSSARY OF TERMS IN NUCLEAR SCIENCE AND TECHNOLOGY. 188 *pp.* $5. *American Society of Mechanical Engineers, Order Dept., 29 W. 39 St., New York* 18, *N. Y.* Includes succinct definitions and explanations of terms and jargon used in nuclear field. Useful to physicists or engineers.

SURFACE AVAILABILITY OF INHIBITORS IN PROTECTIVE COATING SYSTEMS. *Part I: Dichromate Treatment of Magnesium Surfaces, 6 pp. Part II: Chromate Pigmentation of Organic Coatings, 9 pp. By Max Kronstein and H. F. Kummerle. Papers available from the authors, Research Division, College of Engineering, New York University, New York, N. Y.* Discusses influence of moisture penetration through protective coating system on chromate matter contained as pigmentation in the system.

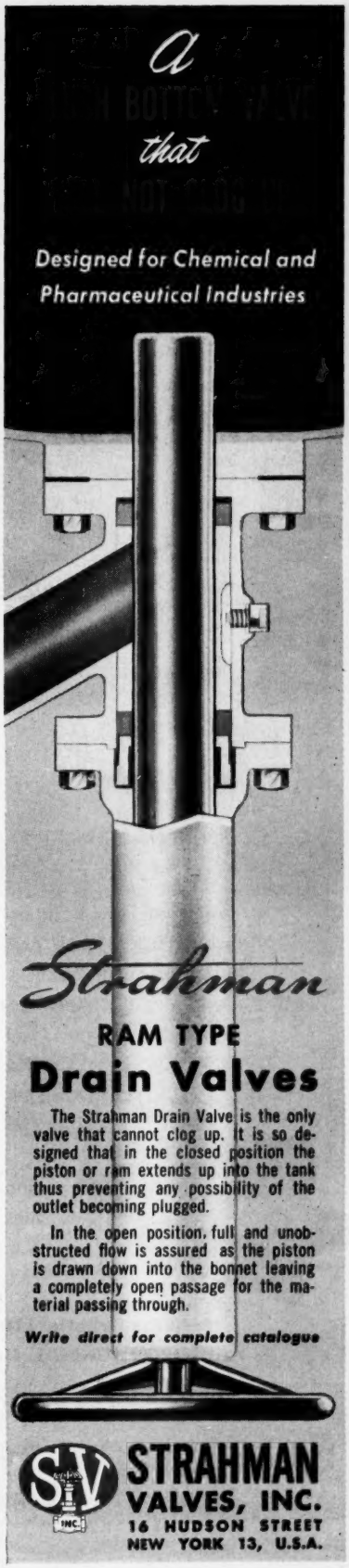
PROCEEDINGS OF THE SODIUM REACTOR EXPERIMENT—ORGANIC MODERATED REACTOR EXPERIMENT (SRE-OMRE) FORUM. $1.50. *Office of Technical Services, U. S. Dept. of Commerce, Washington* 25, *D. C.* Proceedings of forum concern two nuclear power reactor projects being developed by Atomics International for Atomic Energy Commission.

MORE NEW BOOKS

ANALYSIS FOR PRODUCTION MANAGEMENT. By Edward H. Bowman and Robert B. Fetter. Richard D. Irwin, Inc. $7.80.

APPLIED MATHEMATICS IN CHEMICAL ENGINEERING. 2nd ed. By H. S. Mickley, T. K. Sherwood and C. E. Reed. McGraw-Hill. $9.

CHEMICAL ENGINEERING REPORTS. 4th ed. By K. A. Kobe. Interscience. $3.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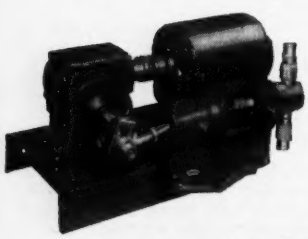

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PEOPLE . . .

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Elmer Gaden

BIOCHEMICALS PROCESSING. PAGE 237

Last year when Professor Elmer Gaden turned out his report on fermentation we hoped he wouldn't stop there but would go on to give us a sequel. This issue brings you that sequel—on recovery, separation and purification of biochemicals.

Gaden's interest in the field of biochemistry, in general, has quite a history. In fact, he can't remember when it didn't interest him. His first ambition for a specific career in life was to become a doctor. Why he never got to medical school to study biochemistry and how he wound up in the chemical engineering field is anybody's guess. He doesn't know.

But, it wasn't long, anyway, before Gaden combined his real interests with work at school. Columbia University awarded him a Ph. D., in 1949, for his thesis on the engineering side of fermentation. Elmer began work on his doctorate just about ten years ago. And, he has been studying the fermentation field ever since.

He left Columbia, in 1950, to work for Chas. Pfizer & Co. where he could put the background he'd built up to good use on various bio-engineering chores. A year later, Columbia convinced him to come back as assistant professor of chemical engineering. Today, Elmer is still at Columbia—now as an as-

*See *Chemical Engineering*, April 1956, p. 159.

AUTHORS

M. A. GIBBONS

sociate professor. And, he's still tackling new and tougher fermentation problems.

AIChE activities will keep him working in the same field too. As a member of the AIChE's program committee, he'll handle a session, in Chicago, this December specifically designed to cultivate the interest of chemical engineers in biochemical processes.

Professor Gaden, himself, strikes you right off as a curious and intense sort of person. He talks with good fresh enthusiasm about his work and soon has you feeling much the same way. We have no intention of "typing" anybody, but Elmer, his casual sports jacket, busy schedule, and refreshing lack of sophistication—all do blend well into his role as a young college professor in a bustling metropolis.

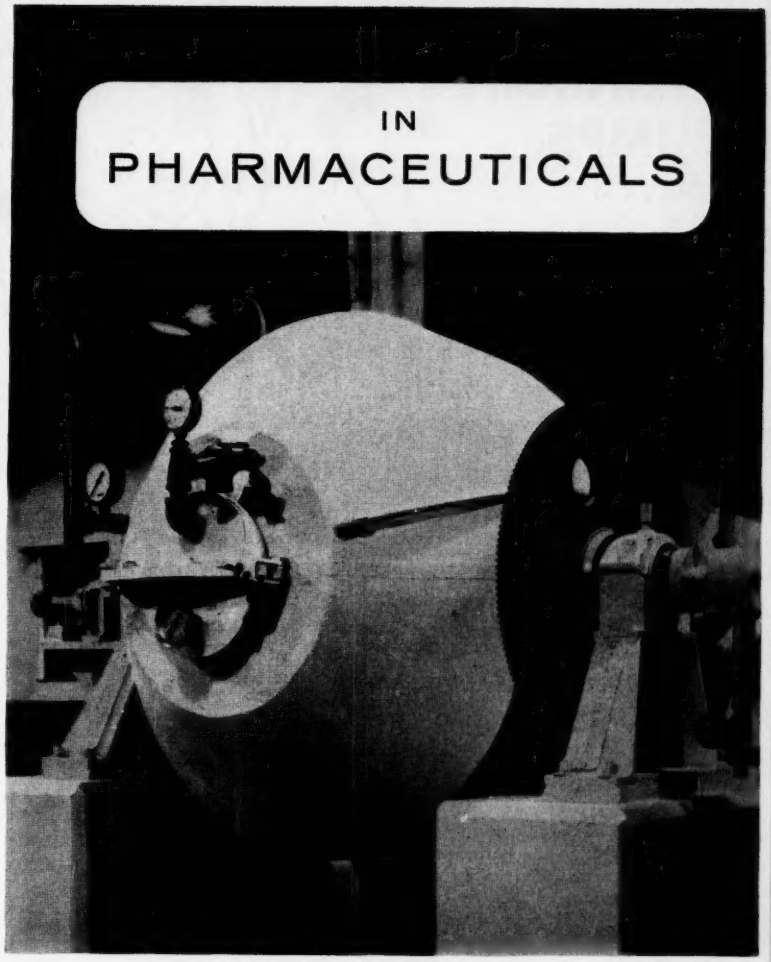
Frank L. Rubin

HEAT EXCHANGER COSTS TODAY. PAGE 257

Readers who have been following up our cost estimating articles will remember Author Frank Rubin for his contributions on heat transfer costs, to that series in 1953. That year, he turned out four: published in May, July, September, October.

This current article updates the highlights of those four articles.

* Rubin is a sales engineer for Downington Iron Works. For a complete rundown on his activities, see *Chemical Engineering, Feb.* 1956, p. 318.



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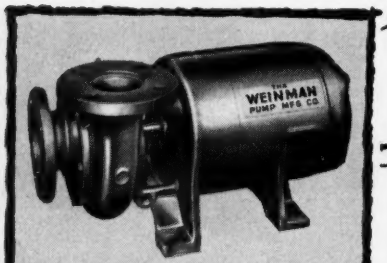

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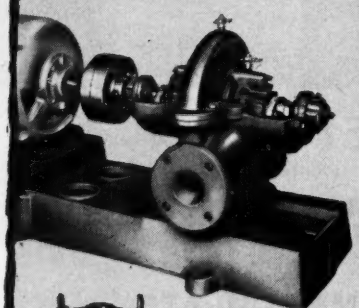

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PEOPLE . . .

LETTERS:

Pro: Gas-Film Lubrication

Sir:

On p. 144 of your March issue you have an item on gas-lubricated bearings.

We are interested in obtaining information concerning this subject. I would appreciate any reference you may have or the names of individuals or concerns that I might contact in order to obtain more detailed information on this development.

D. C. HAMPSON
Argonne National Laboratory
Lemont, Ill.

Sir:

Your Chementator article, "Lubricate your bearings with a gas film," was of extreme interest here. Could you possibly give us more information on gas lubrication and also the names of firms currently producing bearings of this type? We are working on several problems which involve bearings which must operate at temperatures over conventional lubricant limits.

A. S. HALPERN
Kearfott Co.
Clifton, N. J.

►*As stated in our story, gas-lubricated bearings are not yet commercially available, but readers interested in further engineering information about design of such bearings may contact Dudley Fuller, professor of mechanical engineering at Columbia University, New York. Prof. Fuller, who helped us develop our story, is a recognized authority on this subject.*—ED.

By All Odds the Best

Sir:

Your Annual Review, "Population Boom Challenges Chemical Technology" (Jan. 1957, pp. 211-226), is by all odds the best compilation of the pertinent points and the problems which face us in the technological and economical fields in the next couple of decades.

Despite the fact that the article is strongly vectored toward chemical engineering problems, its contents and implications go

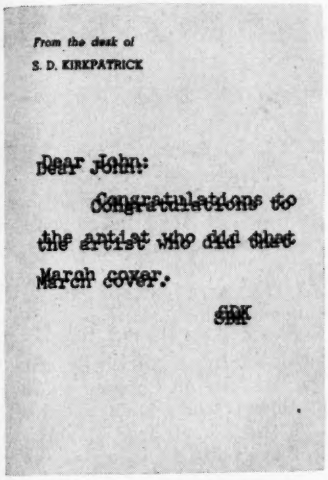
PRO & CON

C. H. CHILTON

much broader and deeper. I feel that this should be a significant contribution to the basic thinking and planning for our profession.

If you have extra copies available, I would be pleased if you would let me have ten or a dozen. I feel they would be very useful for study by some members of my staff here.

C. C. FURNAS
University of Buffalo
Buffalo, N. Y.



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~~Congratulations to the artist who did that March cover.~~

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Pro & Con: Hot Cover

Sir:

Whoever is responsible for the cover on your March issue should have his eyelids cut off and should be hung up by the thumbs out in the sunlight somewhere.

That certainly is the most appalling lettering I have ever seen, and I have to keep by magazine face down on my desk in order to keep from going blind with even just a quick glance.

WM. H. WEED
Mutual Chemical Div.
Allied Chemical & Dye Corp.
Baltimore, Md.

INTER-OFFICE MEMORANDUM

To: Lester Pope, New York
From: Elliot Schrier, San Francisco

Three readers have already

Memo: to all process engineers—

Why Tolerate Liquid Carry-Over?

...when METEX Hi-Thruput Mist Eliminators can deliver 100% efficiency!

● Whether it's on a vertical tube evaporator, a packed column, knock-out drum or a vacuum pipe still, there's no necessity, *today*, to permit poor liquid-vapor separation to pull product quality and profits down. With Metex, you have a unit that's *different*. Hundreds of thousands of openings and wire surfaces, so combined as to baffle uprising gas-liquid streams in multiples of thousands of physical separating contacts, can and *do effect complete gas-liquid-contaminant separation.*

No other unit delivers more efficiency, offers longer life or less maintenance. Used and specified by hundreds of process engineers, Metex Hi-Thruput Mist Eliminators are the standard of excellence wherever efficient entrainment separation is important to good production and profits.

•Write for Bulletin ME-6

METEX

•metal textile corporation
roselle, new jersey

Representatives in principal cities throughout the world.

7-072-1

Want better gate valve service?

Cutaway, showing the simple and unique Darling fully revolving double disc gate valve principle that equalizes disc and seat wear, compensates for valve body distortion and provides prolonged tight closing.

IN *your* service Darling gate valves will offer you many times the customary number of operating cycles before repair or replacement is necessary.

It's the unique Darling *fully revolving double disc parallel seat* principle that does it. Get all the facts and see how you save on down-time, part replacement and maintenance.

Darling offers these gate valves in sizes, types and metals for all kinds of normal and unusual services. Write for details, specifying your service requirements.

DARLING VALVE & MANUFACTURING CO.
Williamsport 3, Pa.

Manufactured in Canada by Sandilands Valve Manufacturing Co., Ltd., Galt 19, Ont.

called to comment favorably on the March cover—an unheard-of event!

INTER-OFFICE MEMORANDUM

To: John Callaham, New York
From: G. S. Ryan, Pittsburgh

BBD&O agency has a bulletin board here in Pittsburgh for interesting ways to present something differently.

The place of honor in March was given to CE's cover. This is only one of many indications of the good comments this cover has received everywhere I've gone.

► *Whether you like its execution or not, we're convinced from the comments we've received that our March cover is unique in the annals of technical publishing.*—ED.

Con: Sky Hook

Sir:

Plant Notebook for January (p. 254) shows a sketch for mounting a "sky hook" onto equipment for the purpose of removing cover plates and the like.

The arrangement shown is inconvenient and constitutes a safety hazard. The flange cannot be lifted vertically, and it will swing in against the hoist support when it is lifted clear of the vessel head flange. Use of eye bolts as shown at the top of the hoist support is not recommended in that their strength in this position is only about ½ that permitted for vertical lifts.

The arrangement could be improved by installing a davit-type hoist support which would place the hoist over the load being lifted; the upper eye bolt could then be eliminated. One pipe fitting could also be eliminated if the nipple and cap used to plug the support coupling were replaced with a pipe plug.

E. Y. KIMMERLY
Union Carbide Nuclear Co.
Oak Ridge, Tenn.

Pro: Durable Reprints

Sir:

The Gambill series on estimating engineering properties should have a big demand as reprints; save one for me.

May I suggest that you use a

stiffer paper cover when binding your reprints. Reprints get rough treatment, especially when borrowed by other engineers, and often come back to the owner with the outside pages missing or torn.

HENRY ECKHARDT
Fair Oaks, Calif.

Pro: Process Simulator

Sir:

In view of our own experience with process simulators, we were, of course, interested in your article concerning Du Pont's process simulator (Jan. 1957, pp. 118-120).

We are so sold on this type of training that I am sure no new development will come into Hammermill without use of this training practice.

S. S. HOFFMAN
Hammermill Paper Co.
Erie, Pa.

Stimulating and Optimistic

Sir:

It has taken me a little time to read your Annual Review ("Population Boom Challenges Chemical Technology," Jan. 1957, pp. 211-226), but I have finally done so and found it extremely interesting. Despite the fact that I am not by training either a physicist or a chemist and so could not fully absorb some of the interesting observations you make, I found your report really stimulating and, on the whole, reasonably optimistic.

You can't store your caustic in an ice bucket like this to keep it from caking in hot, humid weather.

You don't have to with new Wyandotte *Flo-chilled* Anhydrous Caustic Soda. It's free-flowing always.

The next time you order anhydrous caustic, make sure it's *Flo-chilled.* Call your Wyandotte representative or distributor.

Look for this label . . . and be SURE!

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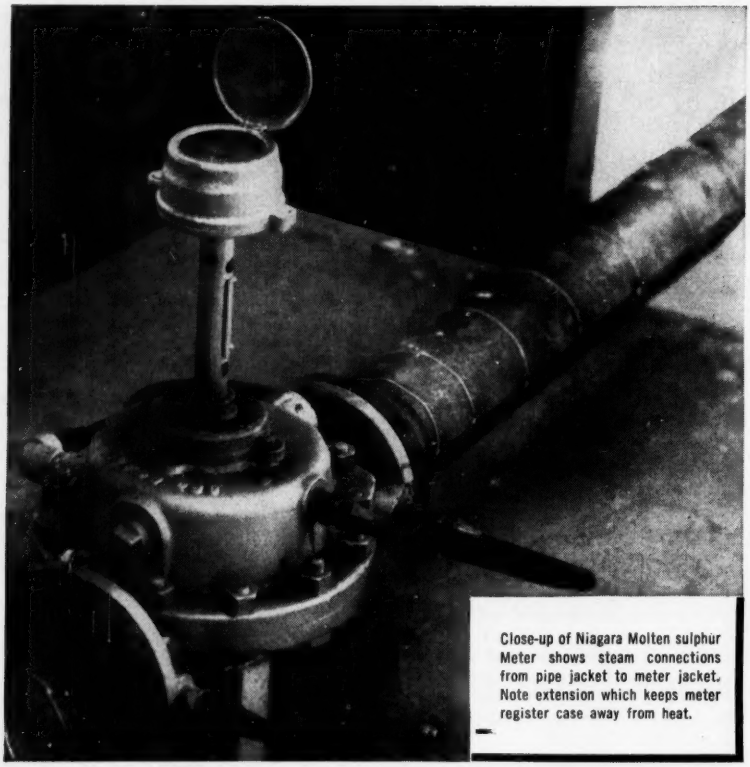
For the difficult Liquid Metering Problems Use Niagara Meters



Close-up of Niagara Molten sulphur Meter shows steam connections from pipe jacket to meter jacket. Note extension which keeps meter register case away from heat.

● Niagara displacement type liquid meters have a surprising range of applications. Their ultra-simple design, and variations of materials enable them to operate under most difficult conditions.

For example:

In the production of sulphuric acid it is desirable to measure the amount of sulphur fed to the burners so that the efficiency of the process can be checked. A Niagara Meter with a steam-jacketed cast iron casing and stainless steel working parts was selected for the job.

Since April of 1955 more than two million gallons of lime neutralized and filtered, dark Louisiana sulphur have been metered at a rate of 560 G.P.H. . . . without a shutdown for repairs or maintenance.

There is a dependable Niagara Meter to meter almost every liquid including caustic soda, sulphuric acid, soap, petroleum products, fruit juices, calcium chloride, alum and many others. The Niagara water meter line is standard for cold or hot water measurement.

Please send me information on Niagara Chemical Meters.

Liquid.....

Flow g.p.m.....Temp.....

Name.....

Company.....

Address.....

BUFFALO METER CO.

2891 Main Street

BUFFALO 14, NEW YORK

PRO & CON . . .

No doubt there is much to be done over the years to come, but I think, too, there is every reason to expect that expanding technology will enable an increasing number of well-trained people in the world to deal effectively with such problems as are likely to arise.

B. B. JENNINGS
Socony Mobil Oil Co.
New York, N. Y.

Pro: Effective Organization

Sir:

Congratulations on your publication of Paul Stewart's article, "Does Chemical Engineering Pay?" (Sept. 1956, pp. 192-4). It makes most refreshing reading after the misleading "bunkum" one sees in almost every technical journal—especially those purporting to be published in the interests of professional technical personnel.

That this article was published in a commercial magazine —not the organ of a professional engineering society—is itself a revealing commentary on the state of affairs existing within engineering and other professional technical societies today.

Policy-making and management functions within such organizations tend to become concentrated in the hands of individuals who have obligations to uphold the interests of employers of technical personnel.

Since no man can serve two masters, it is easy to see why the salary situation has not been anticipated and met on an organized basis. For an organized basis is the only one on which it can be dealt with effectively.

When the present type of organization of professional technical personnel, now operating in the interests of employers, combined with the "momism" and moral cowardice of the age, has reduced us to the status of helots, then we will be reorganized all right—but by labor unions in the interests of labor union bosses, not in our own professional interests.

S. EVAN JACK
Kingston, Ont.

Sir:

Regarding the controversy

over Prof. Stewart's article on engineering salaries, I cannot speak with any actual industrial experience, as I am completing my first year of graduate study in chemical engineering. Still, certain difficulties are all too obvious to me.

Mr. Jung's letter (Mar. 1957, pp. 332-3), pointed to certain of these problems. Whether the American Medical Association is a "monopolistic union" is an arguable point, but the fact that no similar organization exists for engineers is indisputable. Nor does the AIChE statement (Dec. 1956, p. 400) that "wishing for professional prestige will not earn it, and waiting for some organization to confer it is equally futile" do much to brighten the picture for recent graduates.

Further, if Mr. Chartener's odd consideration (Dec. 1956, pp. 397-8) that "an inexperienced B. S. chemical engineer is probably not worth as much to his employer as a skilled construction worker" is indeed correct, then we need no longer bother ourselves about "professional integrity."

A new organization that would concern itself with just this salary difficulty seems to me to be essential. This group could certainly extend itself to creating a better social rapport between engineers and other persons, as well as helping to maintain a proper ratio of working and prospective engineers.

Unfortunately, such a group must be formed by just those men who now seem so little interested in their own future. I cannot, unhappily, even conceive of where the first moves toward the formation of such an organization will occur.

Engineers have no one to blame but themselves for their present salary levels, and if any serious economic alterations occur to change their status they can do nothing but seek employment elsewhere. I certainly hope that such a stimulus will not be required for the formation of an influence group that would work toward what almost all engineers desire.

HAROLD REISMAN
Cornell University
Ithaca, N. Y.

Bendix
EXTRA HANDS
WHERE CAN WE FIND MORE ENGINEERS, VIC? THE SHORTAGE IS SLOWING US DOWN
WE DON'T NEED MORE ENGINEERS - WE JUST NEED TO HELP OUR ENGINEERS BE MORE EFFECTIVE
A DIGITAL COMPUTER WOULD SAVE US WEEKS AND MONTHS OF VALUABLE TIME THAT WE NOW SPEND ON ENGINEERING CALCULATIONS
WHY, WE CAN'T JUSTIFY AN ELECTRONIC COMPUTER - THEY COST HUNDREDS OF THOUSANDS OF DOLLARS
NOT THE BENDIX G-15 - IT IS LOW IN COST AND WE CAN RENT ONE IF WE'RE NOT READY TO BUY

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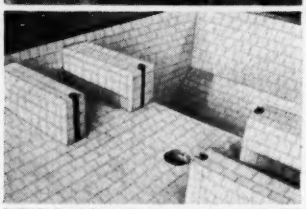
HEDTILE, highly resistant to corrosion, impact and abrasion, can be laid with full corrosion-resistant joint, then bonded to vessel. For chlorinators, reactors, towers, high-temperature tanks, etc. SEMPLATE is used for concrete or steel surfaces – tanks, pits, sewers, flumes, etc.



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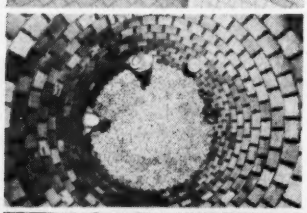
Specially developed for low-temperature, mild-service conditions where clearances are small and maximum capacity must be retained. Neat, easy to keep clean. Special Swedish tile for heavy-duty service. For couch and wire pits, beaters, stock chests, dye becks, etc.



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SEMCO and SEMAC Brick are used in vessels subject to severe corrosive effects. High chemical resistance plus superior thermal spall resistance. For digesters, acid accumulators, acid tanks, chlorine dioxide reactors, bleachers, blow pits and primary coolers. Carbon Brick, Fire Brick and Insulating Brick also used as required.

STOCK AND SLURRY TANKS

Stebbins storage tanks are, in effect, reinforced concrete faced inside and out with vitrified tile, Wide variety of contours and sizes. Walls are designed to carry the fully hydrostatic head in accordance with accepted concrete design. High-density storage tanks, machine chests, clay slurry chests, etc.

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Silos for storage of dry solids are built of SEMTILE or SEMBLOK, or combinations of the two, depending upon the size, location and physical characteristics of the material. Material-handling equipment may be carried on the reinforced tile structure.

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Stebbins installs membrane linings, protected by tile or brick to meet special chemical conditions beyond the protective limits of the brick or tile itself. Complete shop facilities and field crews are available for application of a complete range of sheet and liquid membrane materials.

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PEOPLE . . .

NAMES IN

John G. McNab

Esso Research & Engineering Co. has appointed John G. McNab coordinator of petroleum products and medical research.

In his new post, McNab is responsible for the management of the firm's research aimed at developing new or improved oil products.

Forty-three year old McNab was named director of the products research division at the Esso Research Center, in Linden, N. J., last July. Following month, he was promoted to deputy coordinator of products and medical research.

McNab joined the company in 1936 after receiving his doctorate in organic chemistry from the University of Chicago that year. He earned his preliminary degrees at Queen's College, in his native Ontario.

Samuel M. Terry has been named manager of product development for Reynolds Chemical Products Co., Ann Arbor, Mich. He had been with Pittsburgh Plate Glass.

Frederick Nill has been named assistant to the director of development for Solvay Process division, Allied Chemical & Dye Corp., in Syracuse, N. Y. For the past six years, he has been assistant to the director of operations.

William N. Tuttle has been named technical assistant to the Bay Area Pollution Control district, with offices in

THE NEWS

M. A. GIBBONS

San Francisco. In the past, he has worked for the University of California radiation lab, the Bureau of Mines, and Tidewater Oil Co.

Streed Products Corp., Gadsden, Ala., has been formed to manufacture alloy pipe and fittings, with **William Streed** as president; **Frank B. Moffett, Jr.**, as vice president; and **J. H. Corley**, manager.

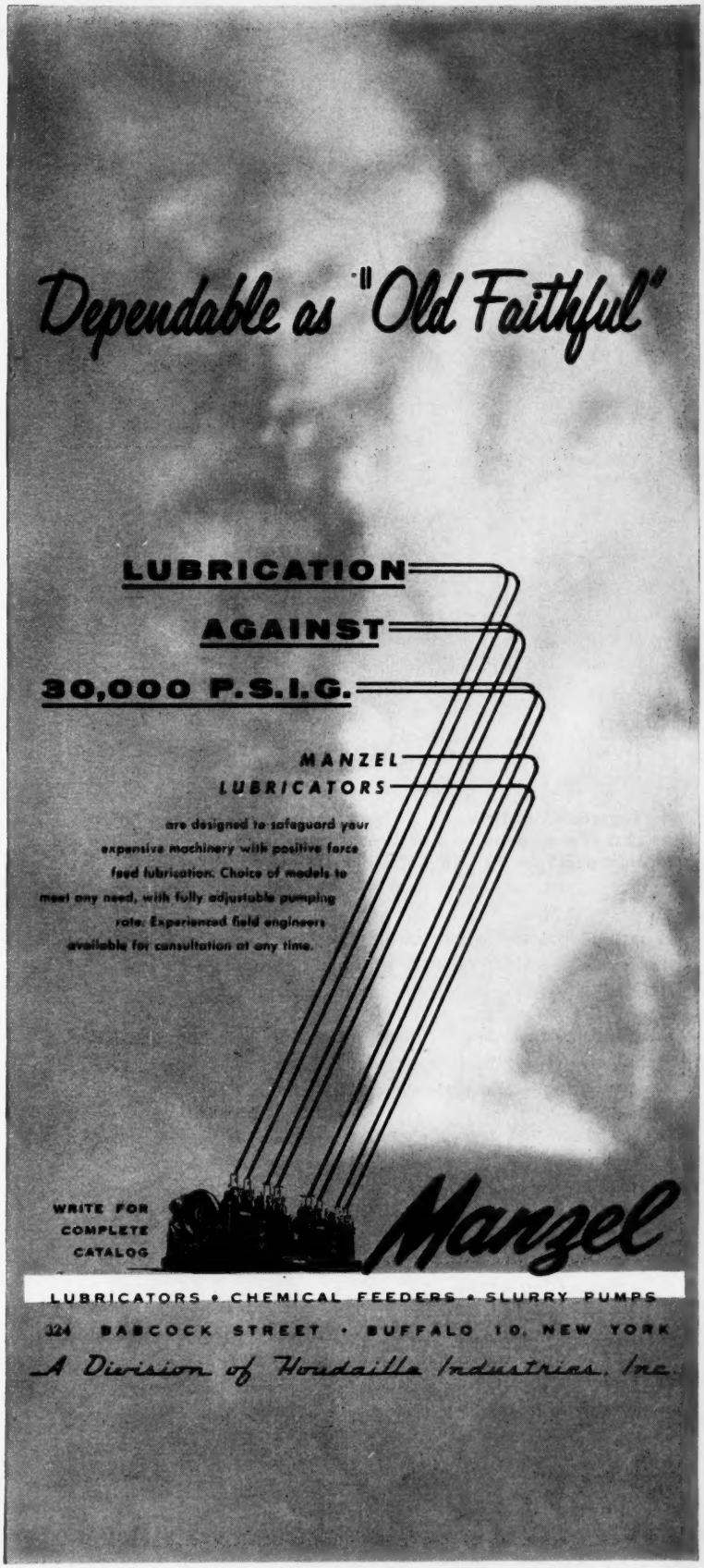
Walter Brunn has been appointed marketing manager of Tidewater Oil Co.'s western division. He replaces **W. A. Reanier**, who is now assistant to the divisional general manager.

R. B. Filbert, Jr.

First to win the "Technical Man-of-the-Year" award given by the Columbus Technical Council is R. B. Filbert, Jr., chief of the division of chemical engineering research at Battelle Memorial Institute.

The Council, comprised of 22 technical societies, plans to make the award an annual feature of National Engineers Week.

Filbert graduated from Penn State with a B. S. in chemical engineering and a master's in organic chemistry. During World War II, he served as an officer in a U. S. Navy Ordnance unit and currently holds the rank of Lieutenant, USNR. In 1955, he was chairman of the central Ohio section of the AIChE and co-chairman of a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"Piping costs run typically as high as 50 to 70 per cent of the cost of equipment to which the piping is connected, and as high as 15 to 20 PER CENT OF TOTAL PLANT COST!"
(Chemical Engineering, Dec., 1955)

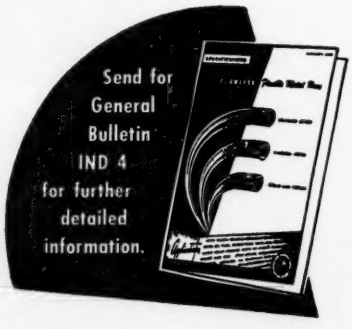
If not adequately compensated for, vibration, expansion, and shock due to sudden changes in temperature and pressure is RIGHT NOW shortening the life of your piping.

Packless® seamless flexible metal hose is designed, engineered and manufactured to absorb this costly beating your piping system is now taking — and do it efficiently and economically.

Let us show you how Packless® flexible metal hose installed in your piping system can save you *hours* in down time and *dollars* in money.

Available from stock in Bronze, Carbon Steel and Monel, with standard or special fittings as required.

Custom engineering service for your specific requirements is available at any time at no extra cost.



PACKLESS
METAL HOSE, INC., 730-51 So. Columbus Ave., Mt. Vernon, N. Y.

regional symposium on industrial gases.

The Filberts and their two children live in Worthington, Ohio.

George R. Vila

U. S. Rubber Co. has elected George Vila a vice president as well as general manager of the Naugatuck Chemical division.

Formerly, Vila was assistant general manager of the Naugatuck division—a position he'd held since 1953.

Vila started out with the firm in 1936 as a salesman in the rubber chemicals department. He got into research and development in 1942 and became synthetic rubber research manager a year later.

Following World War II, he was a part of a government committee that studied synthetic rubber production methods in Germany and on his return he initiated research that led to the development of "cold" synthetic rubber.

Vila has a bachelor's degree in chemistry from Wesleyan University and a master's in chemical engineering from MIT.

Lester M. Goldsmith, general manager of engineering and construction, Atlantic Refining Co., has been cited by the Pennsylvania Society of Professional Engineers as the Philadelphia Engineer of the Year, for contributions to the petroleum industry and to the engineering profession.

Marcel A. Cordovi, head of the materials and testing department of Babcock & Wilcox

Co.'s atomic energy division, received the second annual industrial achievement award of the N. Y. chapter of the American Society of Metals.

Ribert Schiessler and **Raymond Stevens** have been named to head this year's Gordon Research Conferences, of the American Assn. for the Advancement of Science. Schiessler is a technical director at Socony Mobil Labs; Stevens is president of Arthur D. Little, Inc.

A. H. Smith has joined Monsanto Chemical's research department in St. Louis, Mo. **Charles A. Magarian** has been promoted to group leader of the industrial resins group, research dept.

Henry Marchman has been appointed research associate at the Whiting, Ind., labs of Standard Oil Co. (Ind.). He'll serve in the chemical products division.

C. Dana McCoy

Former international director and New York manager of Rust Engineering Co.—C. Dana McCoy—has been appointed international director of Badger Mfg. Co., Cambridge, Mass.

In his new post, McCoy will make his headquarters in the firm's New York branch office.

During his Rust Engineering tenure, McCoy was named a delegate to the UN's first Pulp & Paper Congress in Latin America. Before that time, he had been affiliated with Foster Wheeler Corp., where he started out in 1928 as a petroleum refinery process engineer. He

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Du Pont Offers Real Opportunity.

Work on interesting, challenging, professional assignments. Du Pont's vast research program assures diversification. Your assignments will include work in synthetic fibres, heavy chemicals, pigments, finishes, plastics, photo products, electrochemicals and many other fields.

Progress and promotion are commensurate with ability and performance.

Comprehensive and varied training programs to develop both technical and administrative abilities.

Promotion-from-within. This, plus continuous Company growth, assures both excellent advancement opportunities and stability.

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APPLY NOW to fill one of these immediate openings for:

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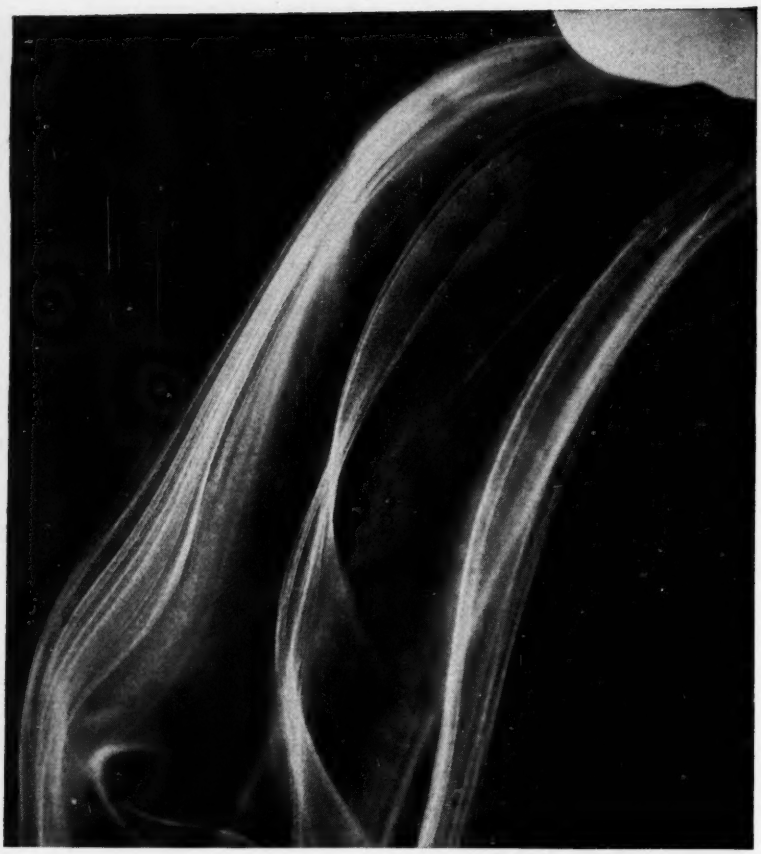

Photographer Bernard Hoffman found even the free flow of CO_2 from a cake of dry ice is difficult to control.

Controlling Flow in Fluid Engineering

To tame and control flow accurately, you must relate it to pressure, volume, turbulence and other variables. That's when you can look to the engineering leadership of S. Morgan Smith.

Butterfly valves are a good example. For the majority of processing situations, a wide range of standard R-S Butterfly Valves are assembled from stock for fast shipment. But for special fluid control problems, one or more can be applied to solve your needs. Standard or special, all R-S Butterfly Valves give you uniform flow control through all positions in the normal regulating range. You get minimum turbulence and pressure drop, save on pumping power because of simplified design and streamlined vanes. Compact and light in weight, they give you quick regulation and tight closure.

To learn more about the complete SMS line of Rotovalves, Ball and Butterfly Valves, call on our nearest representative. For information on special engineering, write S. Morgan Smith Co., York, Pa.

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became Foster Wheeler's international director in 1951.

Earlier in his career, McCoy had been engaged in refinery engineering and operations with M. W. Kellogg and with the Texas Co.

Charles J. Strickler

Horizons, Inc., has named Charles J. Strickler section head of organic chemistry in its chemistry department.

Past research experience took place at Abbott Laboratories, Chicago; Michigan Chemical Corp., St. Louis; and Diamond Alkali Corp., Cleveland. He has worked in exploratory research, in development and, at one time, as supervisor of research activities on pharmaceuticals, anesthetics and organic chemicals.

Strickler earned his doctorate at the University of Illinois; and did undergraduate work at Purdue. He and his family live in Painesville, Ohio.

Walter Donner has been appointed assistant director of research and engineering for laboratory instrumentation at Beckman Instruments, Inc., Los Angeles.

W. A. Reanier has been promoted to assistant to the divisional general manager of Tidewater Oil's western division.

Abel DeHaan, Jr., has been named director of Tracerlab's western division, in Richmond, Calif.

Harold M. Parsekian, a chemical engineer, has been named

general sales manager of U. S. Rubber's Naugatuck Chemical division.

John J. Constantino has joined the chemical department of Water Service Laboratories, Inc., New York, specialists in corrosion control.

Samuel Lenher, a chemist and a director of the du Pont Co., has been named to the board of trustees of the Wisconsin Alumni Research Foundation.

Cornelius R. Duffie has been appointed manager of Western Kraft's pulp and paper mill at Albany, Ore. He is the former chief engineer for Pennsalt in Portland, Ore.

Edward L. Stevens has been named works manager at Spencer Chemical's Orange, Tex., plant. He replaces **Frank Pyle** who is now a vice president with headquarters in Kansas City, Mo.

Bernard J. Gaffney

New York manager of Rust Engineering Co.—Bernard J. Gaffney—is the former sales manager of Chemical Construction Co.'s industrial chemical processes operations.

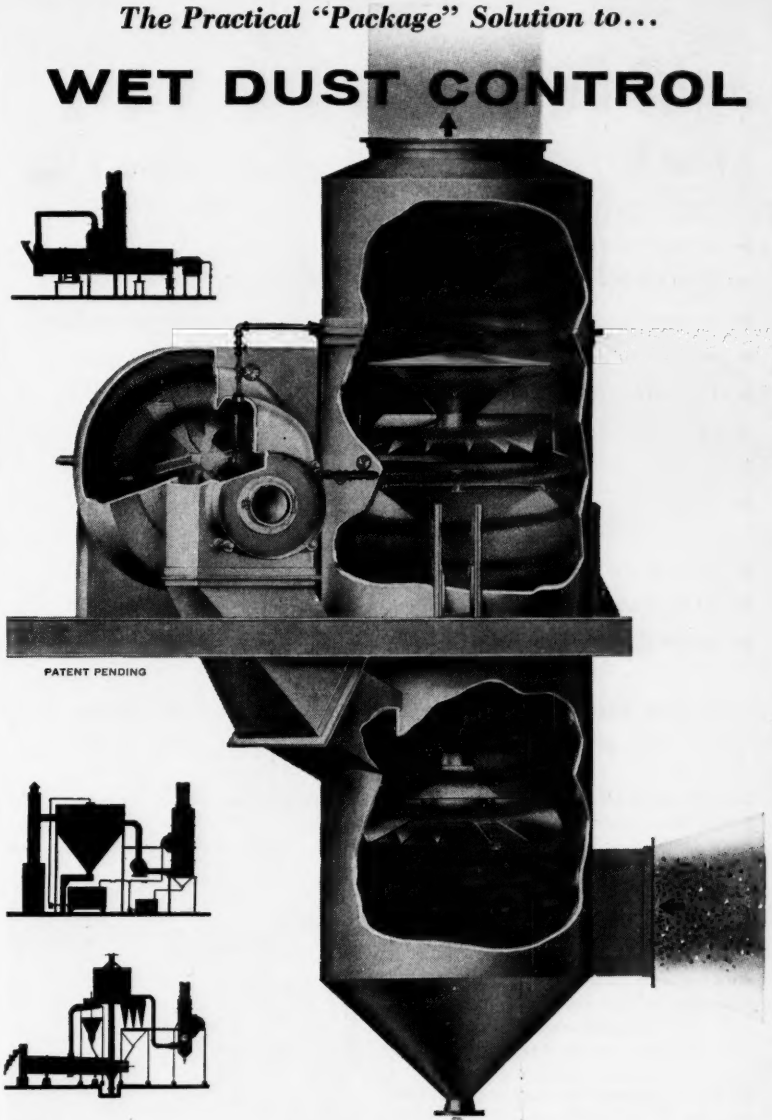
Before joining the American Cyanamid subsidiary, he was a project manager and engineering economist at U. S. Industrial Chemicals, Inc.

Gaffney was a featured speaker on graphic economics for project evaluation at the annual meeting of the American Assn. of Cost Engineers, in February.

Before entering the business field, he served as a chemical engineering instructor at Mich-

The Practical "Package" Solution to...

WET DUST CONTROL



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The Ducon Centrifugal Wash Collector, Type UW-4, is a basic air scrubber with extensive applications for the wet principle collection of problem dusts and recovery fines. For maximum collection efficiency of extremely fine dusts under the most varied conditions... such as in high dust loading and for abrasive dusts... this unit has proved unexcelled in many types of industrial processes. Unitized construction, precision shop-fitted parts and integrated fan assembly provide simple, rapid installation into the normal processing system.

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DRY AIR . . .
PRECISELY as you want it

- to control your product's quality
- to prevent condensation on your product or material
- to prevent changes due to moist air in contact with your product
- to protect your material from dampness
- to protect your processing of moisture-sensitive material
- to DRY your material or product
- to pack or store your product safe from moisture damage
- to get exact moisture control for the precise atmosphere condition you need
- to provide precise atmospheric conditions for testing
- to increase your air conditioning capacity
- to DRY large quantities of fresh air from outdoors

The Niagara's Controlled Humidity Method using HYGROL moisture-absorbent liquid is

Best and most effective because . . . it removes moisture as a separate function from cooling or heating and so gives a precise result constantly and always. Niagara machines using liquid contact means of drying air have given over 20 years of service.

Most reliable because . . . the absorbent is continuously reconcentrated automatically. No moisture-sensitive instruments are required to control your conditions.

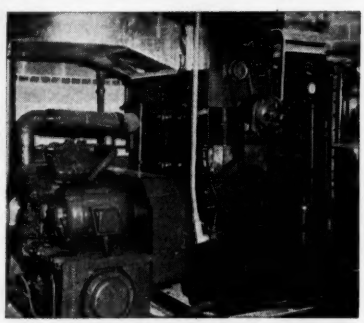
Most flexible because . . . you can obtain any condition at will and hold it as long as you wish in either continuous production, testing or storage.

Easiest to take care of because . . . the apparatus is simple, parts are accessible, controls are trustworthy.

Most compact, taking less space for installation.

Inexpensive to operate because . . . no re-heat is needed to obtain the relative humidity you wish in normal temperature ranges and frequently no refrigeration is used to remove moisture.

The cleanest because . . . no solids, salts or solutions of solids are used and there are no corrosive or reactive substances.



Niagara Controlled Humidity Air Conditioning

This method removes moisture from air by contact with a liquid in a small spray chamber. The liquid spray contact temperature and the absorbent concentration, factors that are easily and positively controlled, determine exactly the amount of moisture remaining in the leaving air. Heating or cooling is done as a separate function.

Write for full information; ask for Bulletins 112 and 121. Address Dept. CE-5.

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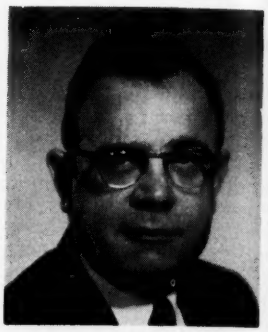
405 Lexington Ave., New York 17, N. Y.
District Engineers in Principal Cities of U. S. and Canada

igan State College. He earned his own B. S. degree in chemical engineering from Northeastern University, a Master's from Illinois Institute of Technology and a Ph. D. from Columbia University.



J. F. Dudley

Commercial Solvents Corp. has announced the election of J. F. Dudley as a vice president.

Dudley will head the firm's production and engineering activities. Till now, he had been the firm's chief engineer. He first joined the firm's engineering department in 1944.

Professional memberships include the AIChE, ACS, SCI and the Chemists' Club of New York.

Dudley earned his chemical engineering degree at Virginia Polytechnic Institute.

Norman Hilberry has been named director of Argonne National Laboratory. The Lab is operated by the University of Chicago for the AEC.

O. W. Collier has been appointed general superintendent of Amoco Chemicals Corp., Texas City, Tex. He joined American Oil Co. in 1948 and served in research and development until his transfer, five years ago, to chemicals.

Jacob Fuchs, associate professor of chemistry at Arizona State College, is the new chairman of the southern Arizona section of the ACS.

Kenneth A. Mack of the chemical machinery division of Baker Perkins Inc., Saginaw,

Mich., has been appointed a director of the corporation.

M. E. Elmore is new division sales manager of Bunker Hill Co.'s chemical products division. He had been superintendent of the Associated Lead & Zinc plant before Bunker Hill acquired the firm last December.

Richard Jarzombek has been promoted to the position of chief chemist of the coatings laboratory of Logo, Inc., Chicago.

A. N. Lindeman

Penberthy Mfg. Co., Detroit, has named A. N. Lindeman chief engineer.

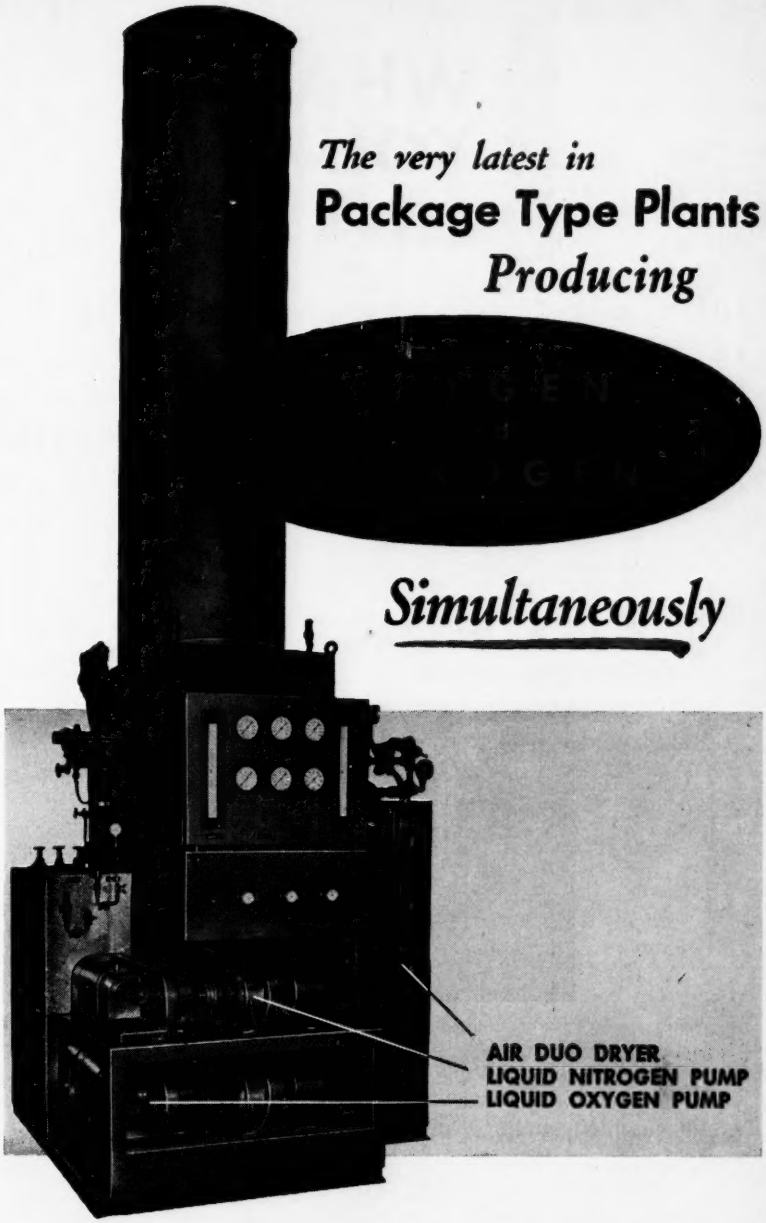
Lindeman has been active in the engineering and developing of the ejector or jet pump as well as its applications in industry. A recognized expert in the field of fluid mechanics, he is presently working on the use of the ejector for atomic energy and nuclear physics programs.

He is a graduate of the engineering school of the University of Michigan and a registered professional engineer.

Leroy G. Kline has been named president of Dow Chimica Argentina, by the directors of the firm in Buenos Aires. From 1947 until last year, he had managed the government-owned, Dow-operated styrene plant near Los Angeles.

Hymin Shapiro has been appointed assistant director of the chemical research and development division of Ethyl Corp.'s research and develop-

The very latest in
Package Type Plants
Producing
Simultaneously



With the introduction of our latest, improved design Package Type Generating Plants, production of high purity Oxygen and Nitrogen simultaneously *increases* production 60% over the production of Oxygen alone, *plus* a corresponding reduction in the *cost* of manufacture. Due to its compact design, a minimum of floor space is required and streamlined panel assembly insures instant visibility of all control gauges. Stock sizes from 1500 to 10,000 cu. ft. per hour. Larger and smaller sizes available. 99.99% Argon available on large size plants.

We invite your inquiry.

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Manufacturers of
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CYLINDERS AND GAS PRODUCING EQUIPMENT
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WHAT'S YOUR LINE?

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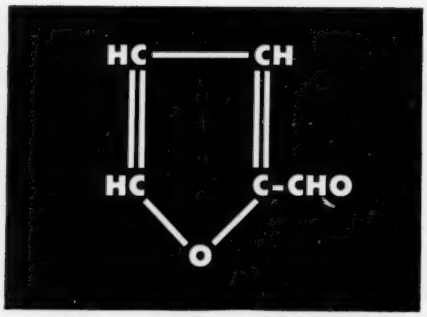
resins
butadiene
gas oil
rosin

pharmaceuticals
wire enamels
chemicals
nylon intermediates
abrasive wheels

if it's any of these, check into

QO FURFURAL



QO Furfural is used in a variety of industries for different purposes such as selective solvent, resin ingredient, chemical intermediate, or reactive solvent.

QO Furfural's versatility and low price are two reasons why you should evaluate it in your processes and products.

Write for Bulletin 204 describing the uses of Furfural.

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In Europe: Quaker Oats-Graanproducten N. V., Rotterdam, The Netherlands; Quaker Oats (France) S. A., 3, Rue Pillet-Will, Paris IX, France; A/S "Ota," Copenhagen, S. Denmark
In Australia: Swift & Company, Pty., Ltd., Sydney
In Japan: F. Kanematsu & Company, Ltd., Tokyo

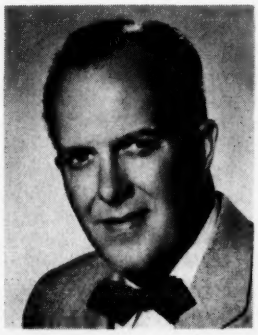
NAMES . . .

ment department in Baton Rouge, La. **W. E. Foster** and **F. Conrad** have been named supervisors.

Milton Harris, director of research of The Gillette Co., received the 1957 honor award of the Washington chapter of the American Institute of Chemists at a meeting on April 23. He earned the award, in particular, for his "leadership in research in the chemistry of textiles and high polymers."

Jay C. Searer has been named works manager for the Durez Plastics division of Hooker Electrochemical Co. He was formerly production manager.

William E. Cass is now a staff member at Arthur D. Little, Inc., Cambridge, Mass., consulting research firm. He had been manager of GE's new product development lab, chemical and metallurgical division.



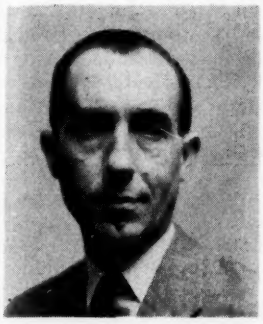
Arthur W. Weston

Former assistant director of development at Abbott Laboratories—Arthur W. Weston—has been named director of research. He succeeds Robert D. Coghill who resigned recently.

Weston originally joined Abbott in 1940 as a senior research man in the organic research department. Over the years, he has been active in the American Chemical Society as well as National Research Council.

Most of Weston's fundamental chemical education took place in his native Canada, at Smith Falls Collegiate Institute and at Queen's University, in King-

ston, Ont. Later, he earned a Ph. D. in organic chemistry at Northwestern University.



H. K. J. de Decker

Texas-U. S. Chemical Co. has named H. K. J. de Decker head of the polymer research section of its research and development department.

Dr. de Decker is the former director of research for Rubber-Stitching, a rubber research institute financed by the cooperating natural rubber producers in Indonesia, from 1949 to 1955. Before that, he had been head of a research group for the Royal Dutch Shell Petroleum Co., a staffer for the Netherlands Organization for Applied Scientific Research and a member of the teaching faculty of Amsterdam University.

As director of the Dutch rubber research institute, de Decker supervised work on tire tread wear, plastics from natural rubber latex, and flame-resistance of foam rubber.

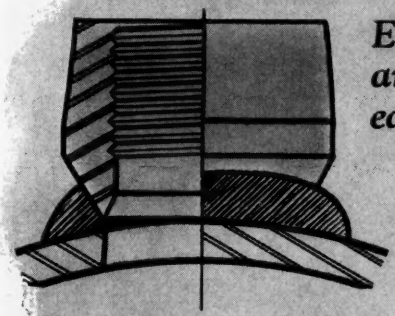
Winston S. Peeler has been promoted from general superintendent of American Oil's Texas City refinery administrative department to general manager of manufacturing, in New York.

King Wilkin is now president of Zellerbach Paper Co., succeeding **Harold L. Zellerbach** who moved up to chairman of the board. Wilkin had been vice president and general manager.

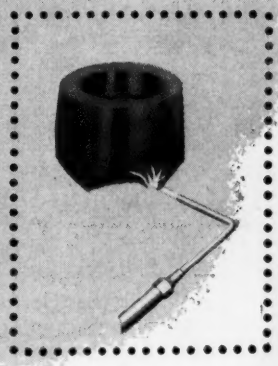
E. A. Barr has peen appointed assistant manager, new product engineering department,

A New Line of Branch Connections

W-S COUPLETS



Economical and easy-to-install



Readily modified for small diameter installation

W-S Couplets are designed to function as universal outlet connections for tanks, process vessels and pipelines. They eliminate the need for large, expensive field inventories and costly delays in fabrication.

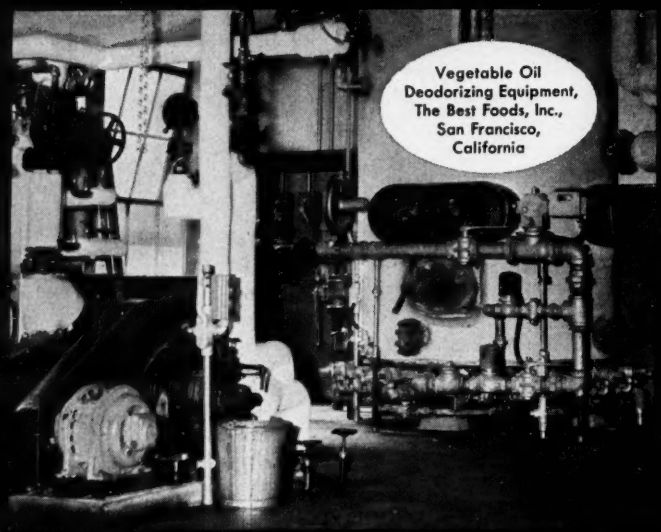
On most tank, and large piping installations they are used as received. On those few applications where attachment is to be made to a small diameter pipe, the W-S Couplet is easily modified by contouring the welding end with an acetylene torch to mate with the curvature of the pipe diameter. Couplets are made with extra length and heavy wall to permit contouring without detriment to the threaded or socket end.

W-S Couplets are available in sizes ¼" through 2", with screw-end or socket-welding dimensions ... also in a 90° elbow.

Send for Bulletin CP-1-57. Write to W-S Fittings Division, H. K. Porter Company, Inc., P. O. Box 95, Roselle, N. J.

HKP W-S FITTINGS DIVISION
H. K. PORTER COMPANY, INC.

2,000,000 Btu per hour at only 15 lb operating pressure



You get high temperatures at lower pressures with Eclipse Dowtherm Vaporizers

Effective use of the high heat-transfer rate of Dowtherm makes it possible for this food processor to achieve high temperatures at extremely low pressures with an Eclipse Dowtherm Vaporizer . . . resulting in greatly reduced operating costs. In addition, the automatic operation and compact design of Eclipse Vaporizers give this company space to spare . . . and extra man-hours, too.

Completely packaged, gas-fired Eclipse Dowtherm Vaporizers give fast, uniform process heating, and their low operating pressures make them safer. Used with gravity return of condensate, they give you a completely automatic system with no pumps, traps, or moving parts. Temperatures are more uniform throughout the heated mass, improving the quality of the product. Local overheating is eliminated.

Let your Eclipse representative show you how you can improve process heating with automatically controlled Eclipse Dowtherm Vaporizers. Contact him for full details . . . or write for Catalog A-100.

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NAMES . . .

Bakelite Co., in New York City. Previously, he was assistant director of the extruded products division at Bound Brook, N. J.

Walter J. Roider, Jr., has been named general manager of the casein department of Borden's chemical division.

James E. Henning has been appointed vice president of Bjorksten Research Laboratories for Industry, Inc., Madison, Wis.

George L. Trubin

National Adhesives (Canada) Ltd. has named George L. Trubin production manager. In his new job, Trubin will be responsible for manufacturing operations at National's Canadian factories, in Toronto.

Trubin joined the firm in 1946 shortly after his release from the U. S. Army. In 1949, after serving in various supervisory manufacturing capacities, he was promoted to the post of plant superintendent of the Toronto plant.

He earned his degree in chemical engineering at Indiana Technical College.

Lawrence J. Serkanic has been appointed chief of the protective coatings lab of Nuodex Products Co., division of Heyden Newport Chemical Corp.

John F. Woodham, assistant professor of chemical engineering at Lamar Tech, Beaumont, Tex., and specialist in chemical kinetics, has taken charge of a 30-month study of chemical reaction in frac-

tionation equipment. The Nat'l Science Foundation has awarded a $9,400 grant for the project.

John J. Bachner has been elected president of Chicago Molded Products Corp., a producer of melamine dinnerware and extruded plastic sheeting.

James H. Moore

Metal Hydrides Inc., Beaverly, Mass., has named James H. Moore as assistant to the president of the firm.

In his new position, Moore will direct an intensive program to broaden the firm's product development and marketing activities in the metallurgical field. He'll work on the application of current products as well as the development of new materials to meet the requirements of nuclear power and reaction engine technology.

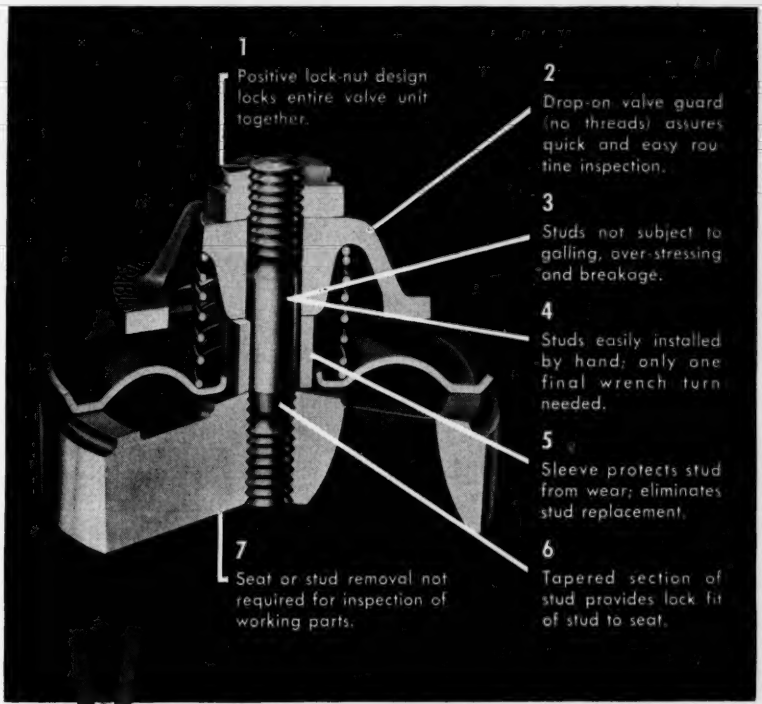
Moore is the former general manager of Vacuum Metals Corp. Earlier in his career, he was director of the metallurgical department of National Research Corp.

Alvin Holzberg, formerly with Nat'l Dairy Research, has joined American Alcolac Corp. as a member of the development department.

John E. Kasch has been elected a vice president and a member of the board of directors of American Oil Co. He is the firm's former manager of research and development.

C. M. Hartwell has been named district superintendent for

Now...DURABLA Pump Valves offer 7 new points of superiority!


1
Positive lock-nut design locks entire valve unit together.
2
Drop-on valve guard (no threads) assures quick and easy routine inspection.
3
Studs not subject to galling, over-stressing and breakage.
4
Studs easily installed by hand; only one final wrench turn needed.
5
Sleeve protects stud from wear; eliminates stud replacement.
6
Tapered section of stud provides lock fit of stud to seat.
7
Seat or stud removal not required for inspection of working parts.

New V-design assures even greater dependability

You want *maximum valve dependability* for your reciprocating pumps . . . and DURABLA gives you just that in the new V-7 unit.

Incorporating seven points of superiority, the new valve features a tapered or V-shaped stud which screws down tight to the seat. This exclusive design anchors the stud, eliminating any possibility of galling, over-stressing or breakage. What's more, the new self-locking nut and drop-on guard assure quick and easy inspection of working parts—without stud or seat removal.

Remember: In the DURABLA Valve, only "point contact" is made by the valve member on the stud sleeve, so it can't bind or hang-up. The open-type guard assures free flow of liquid, prevents clogging.

These stainless-steel valves operate freely under temperature extremes, with corrosives, and in any position. Made in 15 sizes to fit any reciprocating pump, old or new.

Send for *NEW* 8-page booklet CE-57.

Keep your pumps fit with the valves that fit all pumps.

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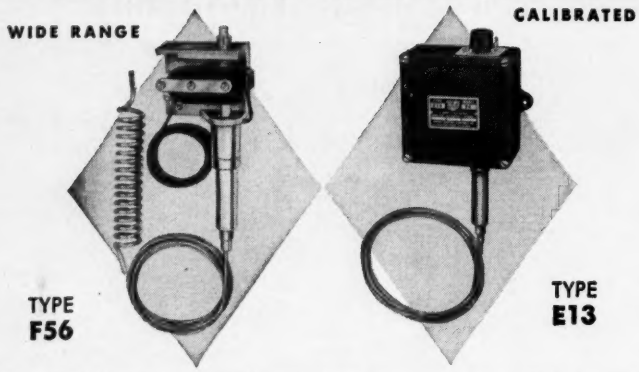
XUM

Improved Design REMOTE BULB TEMPERATURE CONTROLS

F56 / E13



The F56 and E13 are functionally similar controls. Type F56 is a wide range, uncalibrated, skeleton unit designed for use in ovens, incubators, and other applications where space or weight is a limiting factor. Type E13 is a narrow range, calibrated, enclosed unit intended for similar applications but under conditions where an enclosure and external adjustment knob and dial are desirable. Explosion proof unit, Type E98, is also available.

Temperature Ranges	F56 . . . up to maximum limits of −150° to +150°F, 70° to 370°F, or 100° to 650°F. E13 . . . 100° or 200° spans between −150° and +650°F limits.
Switch Ratings	15 or 20 amps at 115 or 230 volts AC. DC switches also available.
Switch Types	N.O., N.C., or Double Throw, no neutral position.
Adjustments	F56 . . . slotted range adjustment screw on top, uncalibrated settings. E13 . . . external knob and pointer, calibrated settings.
Electrical Connections	F56 . . . 12-inch lead wires attached directly to switch terminals. E13 . . . to internally located terminal block via conduit opening in enclosure.
Capillary Tube Length	6-foot standard length. Other lengths available.
Mounting	E13 . . . surface mounted in any position by means of dog ears. May be flush mounted. F56 . . . Surface mounted in any position by holes drilled in base of bracket. May be flush mounted.

UNITED ELECTRIC *manufactures a complete line of temperature, pressure, and vacuum controls. For additional data on the remote type temperature controls, including types F56 and E13, request* Section 200 *of our* new *catalog.*

UE®

United Electric Controls

COMPANY

84 SCHOOL STREET, WATERTOWN, MASS

NAMES . . .

Cities Service Oil Co.'s production operations in Mississippi and Louisiana.

R. S. Abrams has been named manager of production and engineering for the silicones division, Union Carbide & Carbon Corp. Abrams started out with UCC in 1941, in the Linde Air Products division.

Lauren B. Hitchcock, formerly New York consultant and recently president of the Air Pollution Foundation, has opened a consulting office in Los Angeles.

Linus Pauling, professor of chemistry and chairman of the division of chemistry and chemical engineering at California Institute of Technology, is now an honorary member of the American Assn. of Clinical Chemists.

William S. Sale has been appointed research chemist in the paint section, organic chemicals customer applications research laboratory, Dewey & Almy Chemical Co., Cambridge, Mass.

Erhart K. Drechsel has joined Escambia Chemical Corp. to work on commercial development in the firm's New York office. He had been product manager in American Cyanamid's new product development department.

L. C. Arnold, Jr., is now manager of manufacturing in charge of components and equipment for Epsco, Inc., Boston. Formerly, he was on the works manager's staff at Raytheon Mfg. Co., equipment manufacturing division.

Fern Wood Mitchell has been named manager of the research services group for W. R. Grace & Co.'s research and development division, in New York. Until he joined the firm, a little over a year ago, he had been with American Cyanamid in New Orleans.

Capt. Robert T. Simpson, USNR, is now senior product planner

in GE's medium steam turbine generator and gear department.

John M. West, former associate director of the reactor engineering division of Argonne Nat'l Laboratory and project manager of the lab's new nuclear power plant, has been appointed vice president of General Nuclear Engineering Corp., Dunedin, Fla.

Chester S. Beard has been appointed to lead the control valves and actuators engineering division of General Controls Co., Glendale, Calif. For the past six years, he has served with Foster Eng. Co. and Ebasco Services.

Humble Oil & Refining Co. has added seven more chemical engineers to its technical service division: **G. W. Berner, D. A. Foster, D. E. Griffith, R. L. Presley, D. R. Riggs, R. M. Sharp,** and **J. D. Wheeler.** All are located at the firm's Baytown, Tex., refinery.

H. E. Pollard has been appointed chief engineer of the Lindberg - Fisher division, manufacturers of non-ferrous metal melting furnaces and aluminum pumping units.

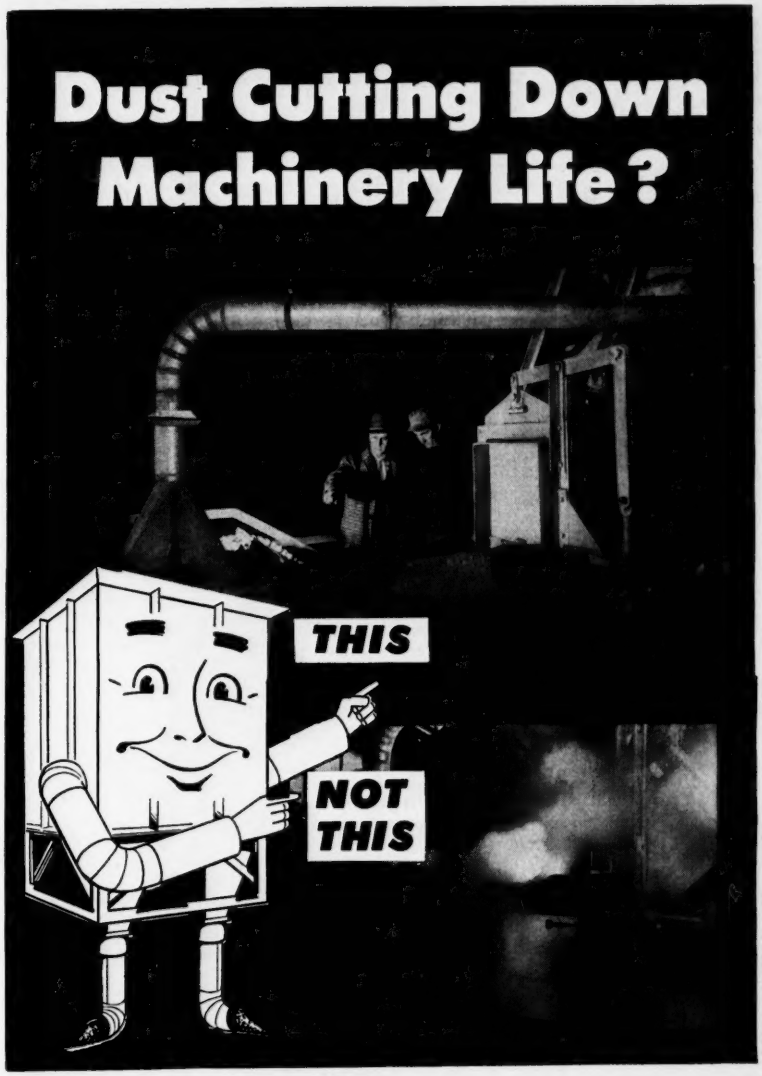
William H. Reeves has been named president of Layne & Bowler, Inc., pump manufacturers, in Memphis, Tenn. He succeeds **James I. Seay,** who is now chairman of the board.

OBITUARIES

Harold D. Skyrm, 59, vice president of General American Transportation, died February 24, after a heart attack.

Joseph G. Hamilton, 49, director of the University of California's Crocker Radiation Lab and 60-in. cyclotron, died in San Francisco, February 18, of leukemia. His death was classified as an industrial accident.

Marcel F. Bachner, president of Chicago Molded Products Corp., died February 21.



You need Pangborn DUST Control in your plant!

Uncontrolled dust in your plant is a costly, needless expense. Dust wears away delicate machinery and clogs working parts, increases down-time and repair costs.

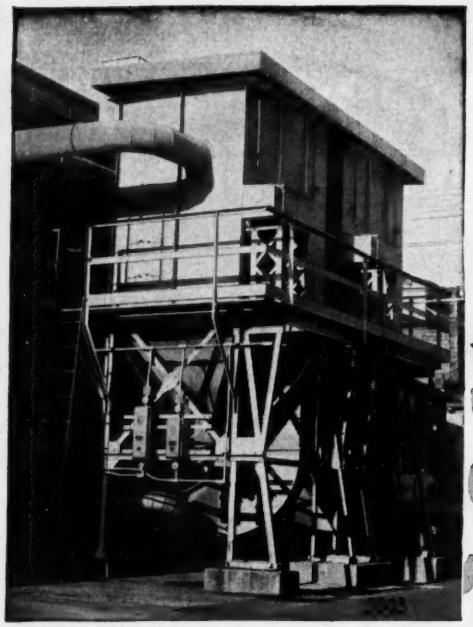
Pangborn Dust Control stops that. Pangborn Collectors trap dust at the source, clean so thoroughly that in the winter many firms cut heating costs by recirculating the already-heated, cleaned air.

In addition, Pangborn gives you the bonus benefits of lower housekeeping costs, more efficient employees, better employee and community relations and extra profits from any salvage value. Complete line of collectors for all jobs.

Discover how *you* can profit from Pangborn Dust Control—write for Bulletin 922, PANGBORN CORP., 2600 Pangborn Blvd., Hagerstown, Md.

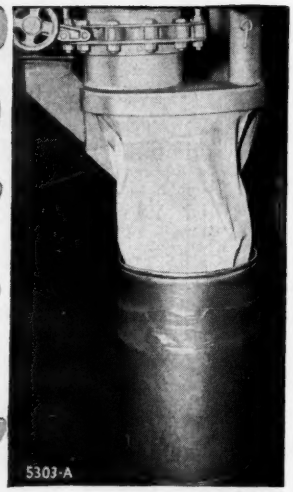
Pangborn CONTROLS DUST

XUM



Sly Dust Filter at the plant of Merck & Co., Inc., Rahway, New Jersey.

SLY KEEPS VITAMIN PLANT DUST-FREE



Packaging Unit showing exhaust duct connected to Sly Dust Filter.

Merck & Co., Inc. uses Sly Dust Filters to maintain quality of product and manufacturing efficiency in the processing of vitamin mixtures.

The final ground powders are blended, milled, sifted and subdivided. Dust tends to escape from each operation. By the use of proper hooding of dust sources the dust is drawn into Sly Dust Collector. About 1.10 to 1.25 percent of each mixture is recovered and reused.

During the past ten years Merck has installed 21 Sly Dust Filters —a fine tribute from a fine company.

No matter what you make or process—if there's dust, you need Sly.

MERCK

Manufacturers of: Dust Control Systems, Blast Cleaning Equipment, Tumbling Mills, Industrial Ovens.

THE W. W. SLY MANUFACTURING CO.

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OFFICES IN PRINCIPAL CITIES

PIONEERS AND LEADERS IN INDUSTRIAL DUST CONTROL

PEOPLE . . . FIRMS IN

NEW NAMES

Freon Products Div. is new name used to identify the division of Du Pont's organic chemicals department concerned with fluocarbon refrigerants, aerosol propellants and solvents. Name was changed from Kinetic Chemicals Div.

Hoechst Chemical Corp., formerly Metro Dyestuff Corp., changed its name to give recognition to its greatly enlarged scope of affiliation with Farbwerke Hoechst, AG.

Allied-Kennecott Titanium Corp. is new name of the $40-million association of Allied Chemical & Dye Corp. and Kennecott Copper Corp. Operations are expected to begin in late 1958.

NEW COMPANIES

S. C. Johnson & Son, Racine, Wis., has formed a new subsidary, S. C. Johnson & Son, Venezuela, C. A. New subsidiary is eighth foreign unit to be formed by Johnson.

Sylvania-Corning Nuclear Corp. has been formed by Sylvania Electric Products and Corning Glass Works.

Mine Safety Appliances de Venezuela, C. A., is wholly owned subsidiary of Mine Safety Appliances Co. for handling all sales and service in Venezuela.

Texas Instruments Co. has announced formation of Texas Instruments Ltd., wholly owned subsidiary to manufacture and sell semiconductor products in the United Kingdom.

Richardson-Bellows, S. A., is new European company formed by Bellows Co., Akron, Ohio, and Richardson Scale Co., Clifton, N. J. New

THE NEWS

J. B. BACON

firm will market motors, pneumatic and materials-handling equipment in Europe, parts of Africa and Near East.

Intex Chemical Corp., with main offices in Lodi, N. J., has been formed to manufacture and market industrial and textile chemicals and auxiliaries.

Davidson-Kennedy Co. has announced formation of Davidson-Kennedy Associates, engineering-contracting firm to design and build chemical processing plants. New firm's offices will be in Chicago, Ill., and Atlanta, Ga.

Ball Bros. Co., maker of glass, metals, rubber, plastics and electronic products, has formed a new research subsidiary, Ball Bros. Research Corp., in Boulder, Colo.

Nuclear Materials & Equipment Corp., to be under direction of Atomic Energy Commission, has been formed to manufacture nuclear materials and equipment for power plants.

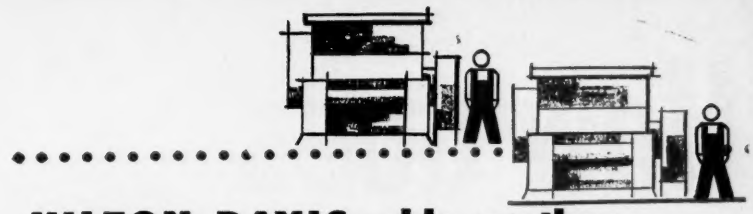
NEW FACILITIES

Case Institute of Technology has awarded Austin Co., Cleveland, Ohio, a contract to design and engineer the Case Industrial Technical Center.

Nitrogen Div. of Allied Chemical & Dye Corp. has begun production of pebbled ammonium nitrate fertilizer in new facilities at its Hopewell, Va., plant.

Atlantic Research Corp. has established a western division, with headquarters in Pasadena, Calif.

Du Pont Co. has started construction of a $5-million lab building at its sales service research center near Wilmington, Del. New lab will

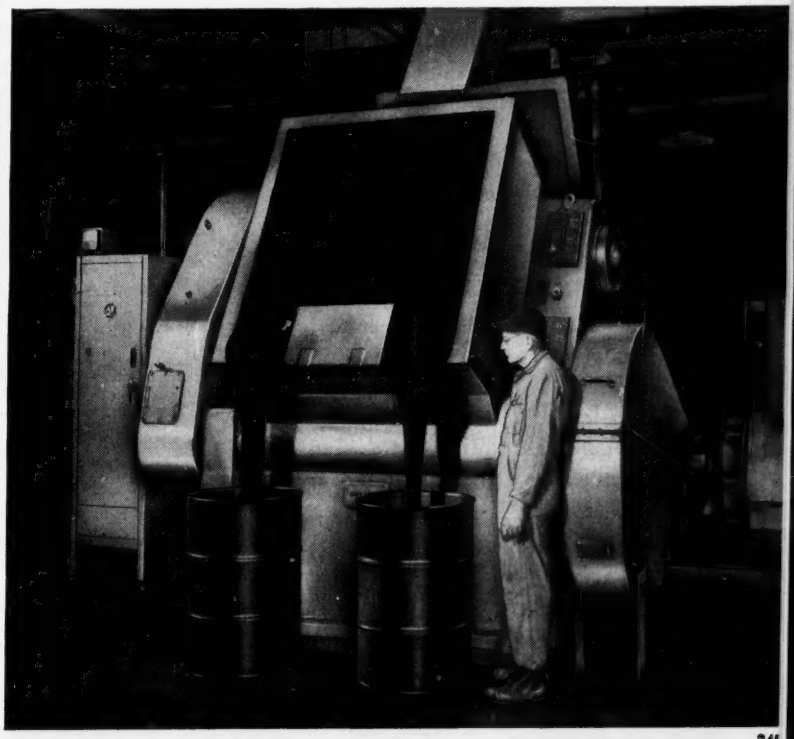


HILTON-DAVIS adds another
BAKER PERKINS VACUUM MIXER
to their production facilities

Steadily increased demands during recent years for Flushed colors has made it necessary for the Hilton-Davis Chemical Co. of Cincinnati, Ohio, to continually expand their mixing capacity. Shown below is the latest Baker Perkins mixer that is now in service in "flushing" operations.

Baker Perkins "flushers" have been instrumental in making it possible for Hilton-Davis to produce economical, superior quality pigments that are noted for their excellent brilliance, fastness, and uniformity.

When you need good, dependable chemical mixing machinery that will help increase your production and keep your maintenance and operating costs low, it will pay you to consult a BAKER PERKINS sales engineer or write us today.



345

BAKER PERKINS INC.

CHEMICAL MACHINERY DIVISION • SAGINAW, MICHIGAN

How does an engineer lose his job?

Hundreds do it every day... without ever leaving the company. They become slip-stick artists, pencil pushers, glorified draftsmen. Unpleasant, yes, but easy to avoid. Selecting the *right company* makes the difference.

Take the Tonawanda Engineering Laboratories of LINDE for example. LINDE engineers have draftsmen to do their drawings... technicians to do their bench work. Each man shares his office with only one or two others. This atmosphere, free of tiresome chores, encourages the solution of tough engineering problems... makes it easier to demonstrate qualities for advancement.

This is pretty heady stuff... and not every engineer can qualify. The work is in the production and distribution of atmospheric gases as gases and as low temperature liquids. The background required is in thermodynamics, heat and mass transfer, and stress analysis as applied to pilot plants, equipment development, process engineering and plant design.

There are a limited number of important opportunities available now. If you consider yourself one of the better engineers, write to Mr. R. P. Kalle, Dept. CE-5, Linde Air Products Company, P. O. Box 44, Tonawanda, N. Y.

For additional opportunities in the midwest, see our ad on page 407

Linde Trade-Mark
50 YEARS OF LEADERSHIP

LINDE AIR PRODUCTS COMPANY
A Division of
Union Carbide and Carbon Corporation

The term "Linde" is a registered trade-mark of Union Carbide and Carbon Corporation

FIRMS . . .

conduct work on titanium, silicon, pigments, sodium, vinyl and other product fields.

Titan Chemical Industries, Denver, Colo., has purchased a 64-acre site near Fruita, Colo., as location for a petrochemical plant using coal, oil shale and possibly gilsonite as raw materials.

Edna Bay Pure Stone Co., Dallas, Tex., announced last month that it would begin construction of a $5-million limestone processing plant at Vancouver, Wash.

Ethyl Corp. has leased a waterfront tract at port of Everett, Wash., as central distribution point to supply additives to refineries in Pacific Northwest.

Australian Paper Manufacturers, Ltd., is bringing to completion its $11-million board mill at Petrie, near Brisbane, Queensland. Initial capacity will be 24,000 long tons/yr. of paper and board products.

North American Aviation's missile development division is now operating world's largest plant to use Chem-Mill process for stainless steel and titanium parts at Downey, Calif.

Chemische Werke Huels' new synthetic rubber plant, now under construction at Bonn, Germany, will start operating next summer. Plant capacity will be 45,000 tons/yr.

Silicone Products Dept. of General Electric Co. is building a new product and process development lab at Waterford, N. Y., to be ready in January 1958.

Dorr-Oliver has acquired near-worldwide marketing rights to the Merrill-Krebs process for recovering gold and silver ores. Certain African territories will continue to be served by Merrill Co. of San Francisco, Calif.

Alaska Pine & Cellulose, subsidiary of Rayonier, Inc., has

scheduled a date late this summer for completion of dissolving-pulp production facilities at its Port Alice, B. C., cellulose plant.

Reynolds Metals Co. will build an aluminum foil plant in Australia.

National-U. S. Radiator Corp., heating and air-conditioning manufacturer, has broken ground for a $1-million engineering center in suburban Johnstown, Pa.

Commercial Solvents and Columbia Gas System will build a $50-million petrochemical plant near Ironton, Ohio.

Westinghouse Electric Corp. has a contract with U. S. Navy to design a nuclear propulsion plant for submarines capable of carrying and firing guided missiles.

Amoco Chemicals Corp. has announced that it will build a plant near Joliet, Ill. to produce aromatic acids from petroleum via Scientific Design's hydrocarbon-oxidation process.

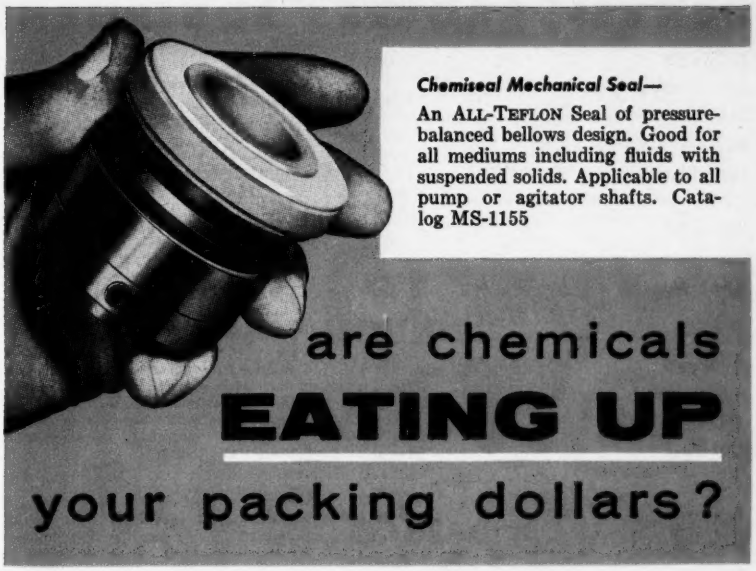
Food Machinery & Chemical Corp.'s largest chemical installation, the Westvaco Chlor-Alkali Div. plant at South Charleston, W. Va. is slated for a multimillion-dollar expansion involving carbon bisulfide and carbon tetrachloride.

Southwest Lumber Mills will construct a $30- to $40-million pulp and paper mill at Snowflake, Ariz.

Frontier Chemical Co. has acquired a controlling interest in Rare Earths Chemical Co. of Mead, Colo.

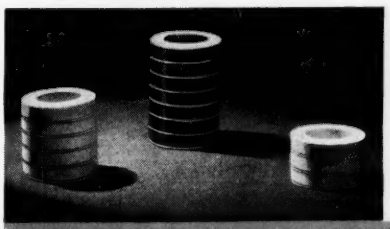
Diamonite Products Mfg. Co., Canton, Ohio, has opened new research, development and pilot facilities for expanded research into properties and applications of high-alumina ceramics.

National Lead Co. recently announced completion of a 75%

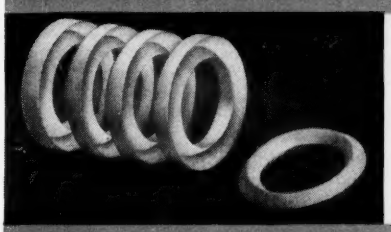


Chemiseal Mechanical Seal—
An ALL-TEFLON Seal of pressure-balanced bellows design. Good for all mediums including fluids with suspended solids. Applicable to all pump or agitator shafts. Catalog MS-1155

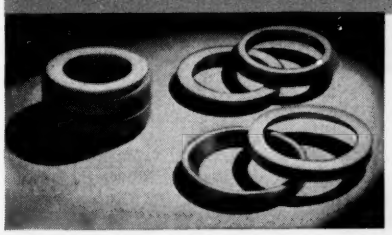
Try Chemiseal Packings and Chemiseal Mechanical Seals that give months of service instead of hours. Made of duPont TEFLON —impervious to practically all chemicals—they won't deteriorate, they won't contaminate, they won't "freeze" shaft action. Write for literature.



Chemiseal Pump Packings—
For general purpose or non-contaminating pump service throughout the processing industries. Two types —pure TEFLON and graphite impregnated TEFLON. Catalog AD-155



Chemiseal V-type Packings—
For manual, air or motor-operated valves. Distinctive tapered V design provides necessary seal at low gland pressure and reduced torque. A companion product to the famous Garlock Chevron Packings. Catalog AD-155



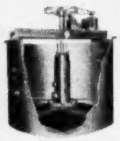
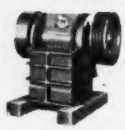
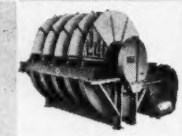
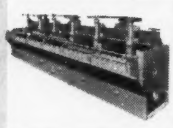
Chemiseal Wedge-type Packings—
For valves made of Haveg, Karbate, ceramics, etc. Offers unusually low gland pressure. Rings provide cushion against thermal expansion. Adaptable for spring loading where exceptionally low friction load is required. Catalog AD-155

United States Gasket Company
Camden 1, New Jersey

United States Gasket *Plastics Division*
OF THE GARLOCK PACKING COMPANY

XUM

DENVER PROCESS EQUIPMENT

DENVER (patented) **SUPER AGITATORS and MIXERS**		**SIZES** 3'x 3' to 20'x 20'	Patented standpipe around propeller shaft assures positive agitation and circulation. Patented wearing plate prevents sand-up on shut-down. Heavy duty as well as acid-proof construction is available in both open-type, air lift and Super Agitator models. Please write for Bulletin No. A2-B4.
DENVER Steel-Head **BALL MILL**		3'x 2' to 6'x 20'	A Denver Steel-Head Ball Mill will suit your particular need. Five types of discharge trunnions. All-steel construction. Low initial cost due to quantity production. Quick delivery. Laboratory and pilot plant mills also available. Please write for Bulletin No. B2-B13.
DENVER Forced-Feed **JAW CRUSHER**		2¼"x 3½" to 36"x 48"	Cast Steel Frame, manganese jaw and cheek plates. Large diameter shafts reduce shaft deflection and thus increase life of heavy-duty, oversize roller bearings in bumper. Setting easily controlled. Please write for Bulletin No. C12-B12.
DENVER Disc **FILTER**		to 12 Disc, 9' Tank Agitator can be supplied	Special, patented design of segments in Denver Disc Filters use both gravity and vacuum to give a drier filter cake. Drainage is complete and positive, with no blow-back. Simple, low-cost, dependable construction. Quick delivery. Also Drum and Pan Fillers. Please write for Bulletin No. FG-B1.
DENVER "Sub-A" **FLOTATION**		Laboratory and Commercial	Flotation is the selective separation of particles from each other in a liquid pulp by means of air bubbles. More large plants are installing Denver "Sub-A's" for their entire flotation job, because they give maximum recovery at a low cost per ton. Dependable, low-cost, simplified continuous operation. Please write for Bulletin No. F10-B81.
DENVER Rubber Lined **PUMPS**		Up to 2400 G.P.M.	Denver (Soft Rubber Lined) Sand Pumps lower pumping costs 30% to 70% due to simple design, lighter weight and accuracy of rubber parts which increase efficiency 1½ to 3 times over other sand pumps. Have molded rubber impellers and casing liners for long life. Write for Bulletin No. P9-B8.
DENVER Automatic **SAMPLERS**		16" to 60" Cutter Travel	Heavy duty units, extra rigid track and ball-bearing wheels assure positive travel and timing of sample cutter. Available in stainless steel for acid anl corrosive service. Wet and dry cutters. Central Control Panel for multiple samplers. Bulletin No. S1-B4.
DENVER-DILLON Vibrating **SCREENS**		1'x 3' to 6'x 14'	Gives fast, clean separation without blinding. Gives even, smooth flow of material because of the patented "true-circle" eccentric action. Two-bearing construction saves 50% HP. Please write for Bulletin No. S3-B11.
DENVER Spiral Rake **THICKENER**		3'x 3' to 80'x 12'	Enclosed, running-in-oil head motion. Patented spiral rakes move settled solids to center discharge with continuous motion, rapid removal of solids tends to eliminate overload. Wood, Steel or Rubber-lined Tanks available. Write for Bulletin No. T5-B5.
DENVER Batch and Continuous **TESTING**		Laboratory and Pilot	Use Denver Testing Laboratory facilities for complete batch or pilot tests—your engineers or ours. Ample test facilities for investigations on crushing, grinding, mixing, classification, separation, sampling, leaching, concentration, thickening, filtration and drying. Consultation is without obligation. Please write for Bulletin No. T4-B15.

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FIRMS . . .

expansion program at U.S. Government's nickel plant at Nicaro, Cuba, boosting capacity to 50 million lb./yr. Expansion cost $37 million.

United States Chemical Milling Corp. will build four new regional chemical milling facilities—in Manhattan Beach, Calif., Dallas-Ft. Worth, Tex. area, Midwest and East Coast locations.

El Paso Natural Gas Co. will build a 6,500-bbl./day refinery at Odessa, Tex., and will build 6-in. products pipeline from Odessa to El Paso area.

Kennecott Copper Corp. will spend $18 million to improve facilities at Utah Copper Div. operations. Most of the money — $16 million -- will expand company's central power station at Magna, Utah.

Sinclair Oil & Gas Co. has signed a contract with Pioneer Gathering System to supply 12 million cu. ft./day of residue gas from Hulldale field near Eldorado, Tex. Sinclair will install desulfurizer and dehydrator to process gas.

Spray Engineering Co. is building a new plant in Burlington, Mass., to manufacture spray nozzles, automatic spraying units and spray-painting equipment. On-stream date: September 1957.

Allied Chemical & Dye Corp. has doubled nitric acid capacity at its Newell, Pa., plant.

American Potash & Chemical Corp. will construct a $5-million sodium chlorate plant at Aberdeen, Miss., scheduled for completion around mid-1958. Initial production will be 15,000 tons/yr.

Skelly Oil Co. will build a 3,000-4,000-bbl./day Perco HF alkylation unit at its El Dorado, Kan., refinery. Process, licensed by Phillips Petroleum Co., uses hydrofluoric

acid as catalyst, and unit will be first such process to use air cooling.

British Hydrocarbon Chemicals has brought on stream two new plants that will double firm's production of ethylene and ethyl alcohol. Units are using petroleum distillate feedstock from Grangemouth refinery of British Petroleum Co.

Monsanto Chemical Co.'s tall oil distillation plant at Nitro, W. Va., will be engineered by Badger Mfg. Co. Plant is scheduled for completion in early 1958.

Intermountain Chemical Div. of Food Machinery & Chemical Corp. will spend over $1 million to boost production of soda ash at its Westvaco, Wyo., plant to 400,000 tons/yr. this year and 500,000 tons/yr. in 1958.

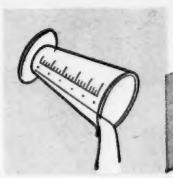
Union Oil Co. of California this month is completing a 225-mi., 12-in. pipeline to carry 75,000 bbl./day of crude oil and unfinished products from south-central San Joaquin Valley to firm's refinery on San Francisco Bay. Pump stations and storage tanks will be ready in August.

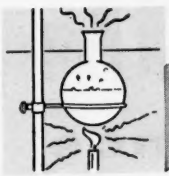
Babcock & Wilcox Co. will expand its Alliance, Ohio, research center to keep pace with its growing nuclear engineering research facilities.

Thompson Products, Cleveland, Ohio, has broken ground for a campus-style research and development center near its Cleveland plant. Center, to be completed in five years, will cost $5 million.

Naugatuck Chemical Div., U. S. Rubber Co., is tripling laboratory and office space at its agricultural-chemical research station and experimental farm at Bethany, Conn.

Farbenfabriken Bayer has acquired Coloidal S. A. of Buenos Aires, will set up new facilities for making syn-

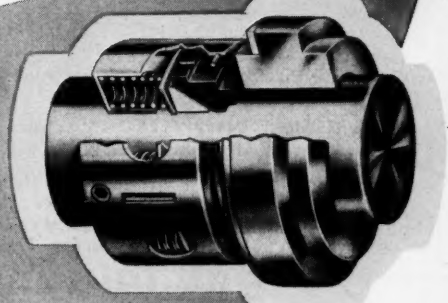

ACIDS, CORROSIVES AND SOLVENTS


HOT LIQUIDS

TOXIC GASES AND VAPORS

JOHN CRANE

TYPE 9 MECHANICAL SEAL



WILL HANDLE THEM ALL!

Wedge and sealing rings molded from DuPont Teflon assure efficient, safe handling of all known industrial chemicals and corrosives at temperatures varying from −120°F. to +500°F. Spring and metal parts are furnished in the metallurgical specification best suited to the particular service. In every way, you get a mechanical seal that is "John Crane" engineered to your requirements—no matter how tough!

The Type 9 Seal has and continues to solve innumerable problems where difficult-to-handle liquids and gases are involved . . . at pressures up to 750 psi. It can do the same for you.

Use the Type 9 Seal on all rotating shaft equipment—centrifugal and rotary pumps, mixers, agitators, autoclaves, other equipment.

REMEMBER: *Your toughest problem can be the Type 9's next success story.* Send for full details today.

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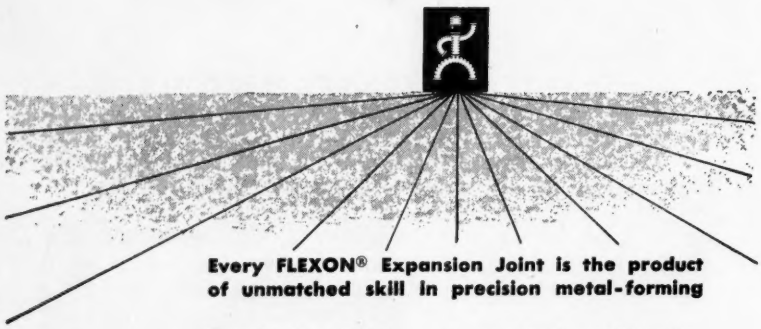
JOHN CRANE CRANE PACKING COMPANY 28 YEARS INDUSTRIAL PROGRESS

19,862

years of experience



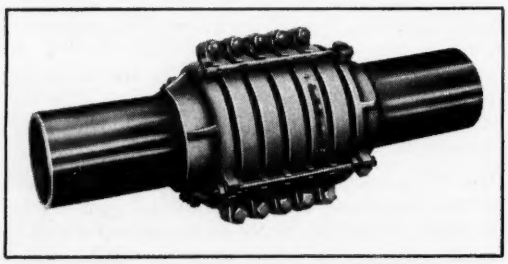
Every FLEXON® Expansion Joint is the product of unmatched skill in precision metal-forming

Experience and skill . . . the combined metal-forming experience of the team of engineers, metallurgists and skilled technicians who produce FLEXON Expansion Joints totals 19,862 years!

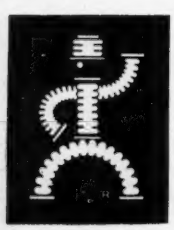
Years of forming and corrugating tubular shapes in metal—flexible metal hose, instrument-type bellows, "impossible" bends and section modulations for aircraft . . . and expansion joints of every kind.

Your dividend of this unequalled experience is expansion joints that you *install and forget.* Free-flexing and controlled-flexing; dual and multiple types; balanced joints and other special designs; all in stainless steel, monel, and other workable alloys. Assured longer service life, through careful analysis of your application, plus skillful manufacture.

Write today for your copy of the Flexon Expansion Joint Design Guide—28 pages of facts about absorbing pipe motion.



EJ-200



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EXPANSION JOINTS

METAL HOSE

NON-METALLIC HOSE

BELLOWS

AIRCRAFT COMPONENTS

FIRMS . . .

thetic tanning acids under a Bayer process.

American Enka Corp. is now in production at its 50-million-lb./yr. rayon staple plant at Lowland, Tenn.

Jefferson Lake Sulphur Co. is starting drilling in the Calgary, Alta., area on an 80,000-acre gas-lease farmout from Mobil Oil of Canada. Jefferson Lake will build a 350-ton/day sulfur plant when adequate reserves are proven.

Davison Chemical Co. is now producing platinum-on-alumina catalyst at its $1.5-million plant at Curtis Bay near Baltimore, Md.

National Potash Co. has placed in operation its $17.5-million, 400,000-ton/yr. potash mine and refinery near Carlsbad, N. M.

Annin Co., Los Angeles, Calif., manufacturer of control valves, has announced that construction is well under way on its new plant in the East Los Angeles industrial area.

Procter & Gamble has opened a more-than-$2-million plant in Malines, Belgium, for manufacturing soaps and detergents. Products will be used in Belgium and exported to other European countries.

American Cholesterol Products, maker of sterol emulsifiers and acetylated lanolin derivatives, has completed a new plant and laboratory in Edison, N. J.

City of Chicago has installed throughout the city about a dozen testing devices designed to show the amount of sulfur dioxide in the air, according to city's department of air pollution.

Texas Co. is making provision for possible expansion of its 8-million-lb./yr. diisobutylene facilities at Port Arthur, Tex.

AMF Atomics, Inc., has been issued a license by Atomic

Energy Commission to export a nuclear research reactor to West Germany.

American Industrial Clays, Inc., is establishing operations at Sandersville, Ga., to mine and process kaolin clays for marketing to paper industry.

Diamond Alkali Co. will build a 50-million-lb./yr. vinyl chloride plant at the firm's Deer Park plant at Houston, Tex.

Lion Oil Co., division of Monsanto, has begun producing oil in Canada. Well has been granted allowable production of 183 bbl./day, is located about 50 miles northwest of North Souris field, which Lion found in 1955 in Bottineau County, N. D.

Cerro de Pasco Corp., Peru's largest nonferrous mining enterprise, has completed $25-million, 72,000-kva. hydroelectric facilities on the Paucartambo River at Yaupi Bajo, Peru. Enlarged power supply will help boost Cerro's slab-zinc output from 120 to 150 tons/day.

Permanente Cement Co., Oakland, Calif., has exercised an option to buy 2,200 acres of land near Scholle, N. M., as site for a $10-million cement plant. Land contains extensive limestone deposits.

Coastal Chemical Corp. is building a $6-million plant on Bayou Casotte harbor near Pascagoula, Miss., for producing high-analysis fertilizer. Plant includes 75-ton/day phosphoric acid unit and 300-ton/day granulating plant.

Michigan Chemical Corp. has placed in operation a new bromine plant at El Dorado, Ark.

Taiyo Bussan Co., Tokyo, Japan, and Sabamil Mining Co., of Sao Paolo, Brazil, have concluded an agreement whereby Taiyo, backed financially by Japanese government, will develop the Jeoro

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indicates set point and process variable at a glance!

plus . . .

- Standard proportional band 1-100% . . . also available to 150%.
- Proportional and differential gap actions easily selected with a screwdriver.
- Manual reset readily accessible. Automatic reset optional.
- Compact—8⅝" square x 4" deep.
- Pneumatic feedback circuit with sensitivity of 1/10% and repeatability of ½%.
- Available in a variety of temperature ranges; pressure ranges from 0-30" H_2O to 0-10,000 psi, and in vacuum ranges of 0-30" Hg.

No other pilot comes even close in a comparison of features with the USG Temperature or Pressure Pilot. The scope of applications is well beyond the range of ordinary pilots for flexibility and accuracy, and compares favorably with much more expensive controllers.

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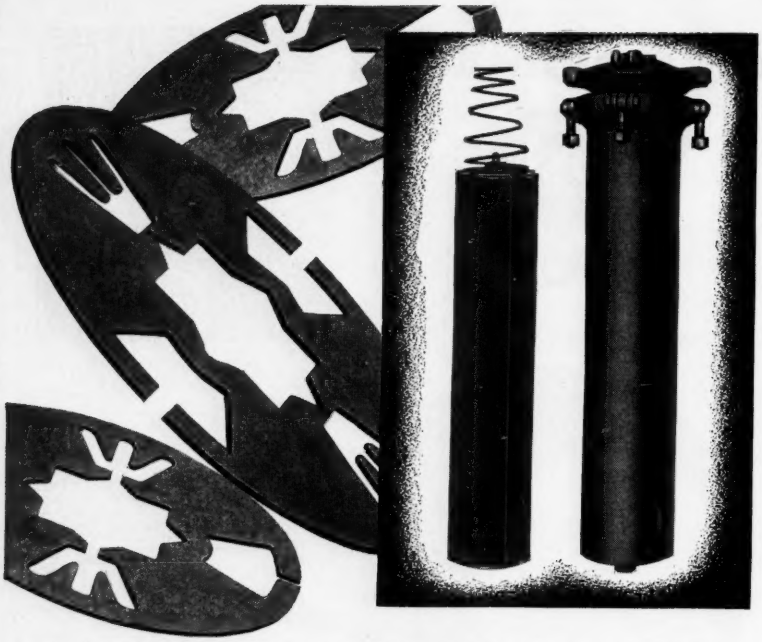
MORE THAN 50,000 TYPES OF GAUGES • SUPERGAUGES • SOLID FRONT GAUGES • RECEIVER GAUGES • TEST GAUGES • RECORDERS • CONTROLLERS • TRANSMITTERS • PSYCHROMETERS • AVIATION INSTRUMENTS



the NUGENT Laminated Disc Filter

This "extended area" filter utilizes an actual filtering surface area greatly in excess of its container area. The Nugent Laminated Disc Filter provides a high flow rate at low pressure drop combined with the extreme fine filtering absorption and neutralizing properties of a depth type filter.

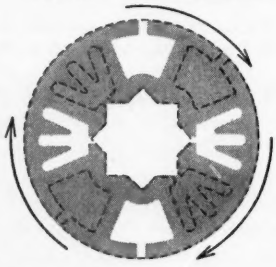
The filter charge consists of a stack of similar crenulated fiber discs, each rotated 45° from the position of the adjacent disc, thus affording proper channeling and maximum filtering capacity. Liquid passes from the exterior to the interior of the filter stack.

The filter recharge has a useful life of from 4 to 10 times that of a cellulose or waste recharge. Changing recharges requires only minutes. Cartridges are interchangeable with all other Nugent bag or depth type cartridges. Write for full details.

DESIGN FEATURES

- Provides "Extended Area" filtering
- Removes solids as small as 2 microns
- Removes acid forming contaminants
- Will not remove additives
- Contains no chemicals or bleaches
- Working pressure 125 psi—tested to 375 psi
- High pressure filters to 600 psi—tested to 3000 psi
- Built in by-pass relief
- Maximum operating temperature 375°F.

HOW IT WORKS



Each disc in filter stack is rotated 45° from position of adjacent disc for proper channeling and maximum filtering capacity.

Established 1897

Wm. W. Nugent & Co., Inc.

3458 Cleveland Street Skokie, Illinois

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FIRMS . . .

nickel mines, about 50 miles inland from Santos, Brazil.

Kennedy-Van Saun Mfg. & Eng. Corp. has opened its new research and development laboratories at Danville, Pa.

Four Corners Pipe Line Corp. started construction last month on a $50-million, 750-mi. pipeline. When pipeline is completed at year's end, capacity will be 60,000 bbl./day, may be boosted to as much as 160,000 bbl./day.

Quebec Iron & Titanium Corp., through a $16-million expansion program, will boost by 60% its production of titanium dioxide slag at Sorel, Que.

Houdry Process Corp. is expanding catalyst plant and production facilities at Paulsboro, N. J.

Phillips Petroleum Co. has licensed Showa Denko K. K., of Japan, to use Phillips-developed catalytic process for making rigid polyethylene.

Kaiser Aluminum & Chemical Corp. will build an aluminum reduction plant in Douglas County, Wash., if county Public Utility District gets government license to build Wells Dam on Columbia River. Wells power facilities would have ultimate capacity of 483,000 kw.

Lake Asbestos of Quebec, Ltd., subsidiary of American Smelting & Refining Co., is now building a $9-million asbestos fiber mill at Black Lake, Que.

Carbide Industrial, Ltd., subsidiary of British Oxygen Co., will build an acetylene plant near Londonderry, Northern Ireland. Acetylene will go to adjacent neoprene plant of Du Pont Co., Ltd.

Eutectic Welding Alloys Corp. has opened a new plant in North Feltham, England, for manufacturing low-temperature welding alloys.

Kelco Co., San Diego, Calif., maker of algin products from seaweed, has begun construction of a $250,000 research laboratory.

NEW LINES

Olin Mathieson's industrial chemicals division is readying a line of nonionic surface-active agents—liquid alkyl phenol polyglycol ethers—for general industrial use. Line will be marketed under the name Poly-Tergent.

Sherwin-Williams Co. recently started manufacturing melamine-formaldehyde resins under a license from American Cyanamid.

Portland Gas & Coke Co. will begin producing high-grade benzol and toluol after completing a $130,000 expansion of oil-refining facilities at its Portland, Ore., oil-gas plant.

Durez Plastics Div. of Hooker Electrochemical Co. will soon enter the polyester molding compound field when its $570,000 plant at North Tonawanda, N. Y., is in operation early this fall.

Monsanto Chemical Co. has announced that its new Randox- and Vegadex-brand farm chemicals for grassy weed control will be sold nationally under the company's label during the coming months.

E. R. Squibb & Sons has begun manufacturing radioactive isotope products for the medical profession. Initial shipments of radioactive gold, phosphorus and iodine are just getting under way.

NEW LOCATIONS

Link-Belt Co. has moved its Louisville district office to larger quarters at 235 East Burnett St., Louisville, Ky.

Packaging Machinery Manufacturers Institute has moved to new quarters at Suite 863, 60 E. 42 St., New York 17, N. Y.

BEFORE installing Chempro Lubricated Seals, the F. & M. Schaefer Brewing Co., Brooklyn, N. Y., experienced high packing and shaft replacement costs on their caustic soda pumps. Although carefully screened, minute particles of grit, aluminates from labels, and pulverized glass were carried back to the pumps. These highly abrasive particles lodged between the shaft and packing, not only chewing up the packing after a few weeks, but causing severe scoring of the shaft, necessitating frequent shaft replacement.

The first Chempro Style WLC Lubricated Seals were installed on Schaefer's caustic soda pumps in May, 1955, and have given more than 12 months of leak-free service. A Chempro Flushed and Lubricated Seal installed in December, 1955, on an Ingersoll-Rand Type 3CRVL pump has given the same trouble-free service in pumping highly abrasive caustic soda and diatomaceous earth solutions for reprocessing in a filter press.

Chempro Seals are giving highly economical service on pumps handling acids, alkalis, solvents and other chemical liquids and slurries under a wide range of operating conditions. Our engineers will be glad to recommend the Chempro Seal to meet your particular needs.

Advantages: Completely Interchangeable with Packing Simple in Design • Chemically Inert Chempro Teflon† Packing Low Power Costs • External and Internal Seals Available Arranged for Lubrication, Flushing and /or Conditioning.

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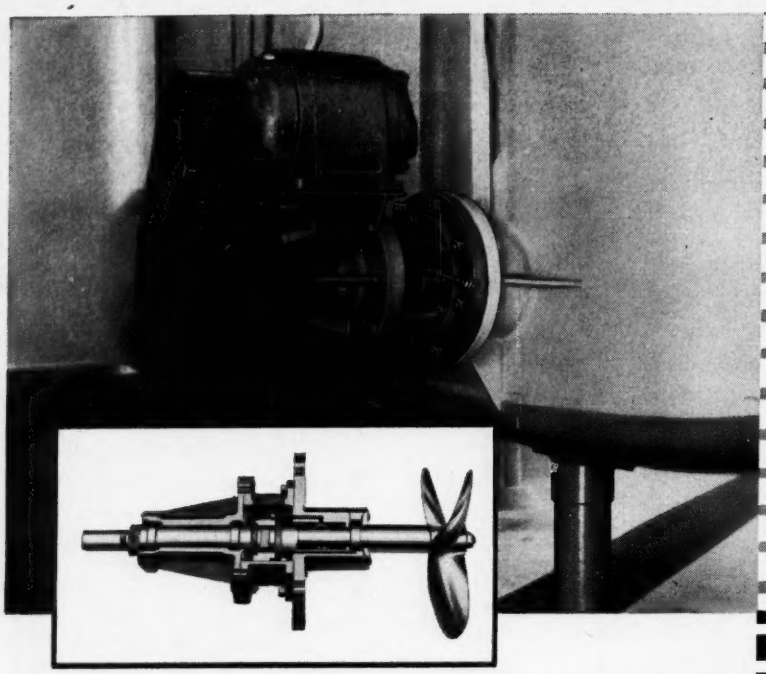

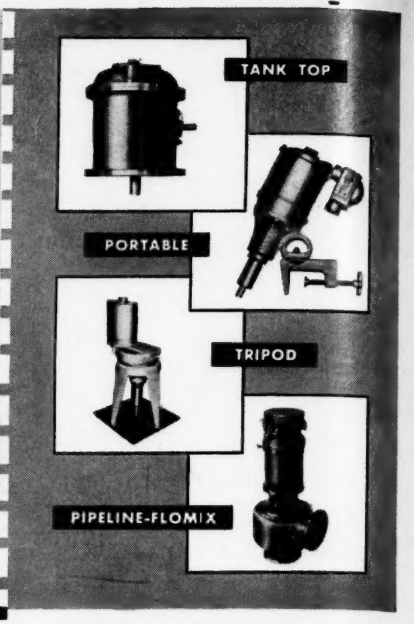

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Chemical Engineering

Classified Section

EMPLOYMENT OPPORTUNITIES **404**

With nation-wide coverage, this section brings you a roundup of today's big opportunities in management, engineering, sales, production . . . the whole field.

EQUIPMENT SEARCHLIGHT **410**

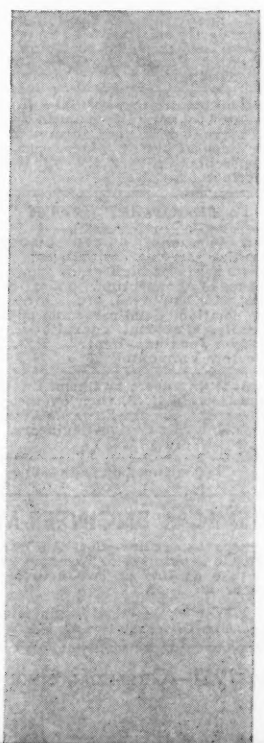
Each month you'll find used, resale and rental bargains in this section. It's the most complete listing of its kind in the chemical processing field.

PROFESSIONAL SERVICES **418**

Consultants can save you time and money through their specialized skills. Here they offer technical, economic, management and other professional services.

MAY 1957

For more information on the coverage, services or rates of CE's Classified Section, contact the McGraw-Hill office nearest you or write to Classified Adv. Div., Chemical Engineering, P. O. Box 12, New York 36, N. Y.



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Development Chemist to study flushing process. Experience preferred. Vacancy in the Northwest Pa. division of national manufacturer. Expansion potential. P-4735, Chemical Engineering.

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(Continued on page 406)

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Give full details of education, experience, desired salary, availability date and references. All inquiries will be considered promptly and held confidential.

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The Engineering Service Division of du Pont's Engineering Department provides consulting service and technical assistance to production, maintenance, design, research, and construction groups within the company. The Division's objectives are to assist other company units in improving plant efficiency and product quality, in reducing investment and operating costs, and in increasing capacity.

Six openings are immediately available for experienced graduate engineers to provide consulting service to operating plants in the following specialized chemical engineering fields:

DRYING

Most desirable qualifications include: substantial experience in the field of drying; a broad knowledge of mechanical drying equipment and their applications; and basic understanding of auxiliary equipment, such as pumps, ejectors, etc. Familiarity with heat transfer, fluid flow, thermodynamics, and the mechanics of particulate solids is desirable. The successful applicant will be called on to develop unorthodox and unusual solutions to practical problems in drying particulate solids and sheet and fibrous materials.

HEAT TRANSFER

Duties include: trouble-shooting on equipment, such as pipe line reactors, fluidized solids reactors, and film driers, where heat transfer is one controlling factor; selection of equipment, such as heat exchangers, evaporators, furnaces, and driers; evaluation of equipment to determine optimum alternatives; and theoretical analysis of problems in heat transfer in proposed equipment for new applications. Other typical heat transfer problems encountered involve reboilers, inert gas generators, direct fired production furnaces, and indirect fired retorts.

AUTOMATIC PROCESS CONTROL

Position requires broad and detailed experience in research, application, consulting, or design of automatic controls for chemical, mechanical, or aeronautical applications. The successful applicant will provide consulting advice to operating plants and development laboratories on the application of automatic control to new processes and for the improvement of existing processes. Position will require the study of process controllability by analysis of open and closed loops and the measurement of control characteristics of instrument components.

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B.S. in Geology, or in Mining Engineering with major in geology. Minor in hydrology helpful. At least 5 years' experience in groundwater geology. Additional work in surface water helpful. Engineer will advise Company design, construction and operating personnel on geological problems, especially those on groundwater availability. Candidate should have proven record in past work. Must be personable, articulate in speech and writing, and free to travel.

METEOROLOGICAL ENGINEER

B.S. in Ch.E plus M.S. meteorology or equivalent, with one year in weather forecasting, preferably in applied meteorology and air pollution control. With minimum on-the-job training, engineer will consult in air pollution control, engineering applications of climatology and forecasting to chemical plant design, construction and operation. Candidate must be personable, possess professional flexibility and willingness to travel. Engineer should have potential to become an authority in his field.

STATISTICIAN

Duties include: statistical design and analysis of experiments; application of probability theory and statistical inference to production and management problems, ranging, as examples, from sales forecasting for production and inventory control to use of probability in setting optimum plant maintenance policies; and Operations Research—the mathematical and statistical formulation of production, marketing and financial control problems prior to analysis by data processing systems. Operations are on a company-wide basis. Desired qualifications: a PhD or equivalent in mathematical statistics or physical science (including engineering), with experience with and interest in practical design of experiment, mathematical statistics, or probability theory.

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EMPLOYMENT SERVICES
(Continued from page 404)

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Ashland Oil & Refining Co is seeking a man with a degree in chemical engineering or in chemistry having a strong mathematical interest with at least three years experience in the petroleum or petrochemical field or a man with a degree in mathematics with chemical engineering training for work on petroleum and petrochemical problems utilizing a wide range of mathematical background in the operations research field. Experience desired three to ten years.

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Employment Dept.
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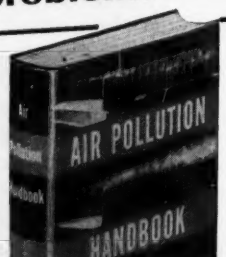
For the answer, turn to page 337

To Help You analyze and solve AIR POLLUTION problems



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Every advertisement printed in the Employment Opportunities Section is duly authorized.

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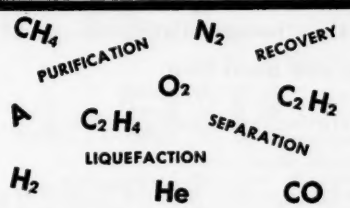

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P-4720, Chemical Engineering,
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To provide for its continued growth Chemical Week is seeking two additional assistant editors—preferably chemists or chemical engineers with two to three years business experience. Essential: Ability to meet people, dig out facts, interpret them intelligently and write lucidly. Please submit resume to:

PERSONNEL DIRECTOR
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EQUIPMENT SEARCHLIGHT

CE's Searchlight spots the big bargains in used, resale and rental equipment. Check this issue's listings — most complete in the field — for items you need now.

▶ **Coverage**—National (see index of advertisers in this section for your nearest dealer). Equipment and facilities—used, resale and rental—for the process industries. For sale, wanted for rent. ▶ **Rates**—$16.95 per inch for all ads except on a contract basis; contract rates on request. An advertising inch is measured ⅞ in. vertically on a column; 3 columns, 30 in. per page. Ads acceptable only in display style. ▶ **Closing Date** — June issue closes May 2nd. Send all new ads to Chemical Engineering, Classified Adv. Division, P.O. Box 12, New York 36, N. Y.

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4—Tolhurst 40" Suspended Type Centrifugals.
8—Centrifugals 12", 30", 40" & 48" Steel, Copper, Stainless & Rubber Lined.
6—Sharples Centrifuges #5A Stainless, Also #6.
3—De Laval Multiple Clarifiers #200, 300 & 301.

FILTERS
#2 Sweetland Filter 12 Stainless Covered leaves.
1—Vellez 41 Stainless Covered Leaf Filter, types 49.
1—Ertel Eng. 10 Disc Filter Nickeled Bronze.
Sperry & Shriver 7" to 36 sq. in. Iron & Wood.
Gen. Amer. 2" x 1" Rotary Vac. Filter.

KETTLES & TANKS
Pfaudler 200 gal. Glass Lined Closed Jack. Kettle.
1—Dopp 350 gal. C. I. Jack. Vac. Kettle.
Devine & Stokes Impreg. Units 30" & 36" dia.
Devine 1000 gal. closed jack. Steel Kettle.
1—2300 gal. Vert. agit. Jack. Steel Kettle.
8—Jacketed Kettles 50 to 2300 gals.
1—250 gal. Lead Lined Kettle.
Pfaudler 150 gal. closed agit. Jack. Steel Kettle.
50—Stainless Alum. Copper, Glass & Lead Lined Kettles & Tanks. Also new Stainless.

PULVERIZERS & MILLS
3—Mikro Pulverizers #2SI #2TH & Bantam.
Pebble Mills 24" x 30", 30" x 30", 30" x 34", 30" x 42", 4' x 5'. Also Jar Mills.
#1 Raymond Automatic Pulverizer 20 H.P. motor
1—Raymond #00 Pulverizer 30 H.P. Complete.
2—#0000 Raymond Mills.
Sturtevant #0 18" Hinged Hammer Mill.
Sturtevant Lab Swing Sledge Mill.

Jeffrey 18" x 18" Single Roll Crusher.
Day Hercules Spike Crusher 1½ H.P. motor.
Hammer Mills Pulverizers 3 to 50 H.P.
1—Shultz O'Neil 20" Pulverizers. Also #1.
Williams #3 & 2xx Hammer Mills.
1—Robinson 18" & 22" Attrition Mill.
1—Lehman 4 Roll W. C. 12 x 36" Steel Mill.
3—Steel 3 Roll Mills 9"x32", 12"x30" & 16"x40".
3—Houchin 18"x36", 4 Roll Granite Stone Mills.
Ball & Jewell Rotary Cutters Lab. & up.
2—U. S. & Premier 1½ H.P. Colloid Mills

MIXERS & SCREENS
Day Imperial 75 & 150 gal. Jack. Mixers.
Baker Perkins double arm 100, 50 & 9 gals.
2—Read 50 & 100 gal. double arm mixers.
Lancaster 6' dia. vert. Mixer 25 H.P.
Kent 3 H.P. Continuous Dry Mixer.
Horiz. Mixers single & double arm to 200 gal.
3—Day 8, 15 & 40 gal. Pony Mixers.
2—Day Brighton 20 gal. Change Can Mixers.
Read 40 and 80 qt. vertical Mixers.
6—Lead—Paste Mixers 50 to 150 gals.
Tyler 3'x5' Vibratory 2 Deck Screen. Other sizes.
Blystone 3000# horiz. spiral mixer.
10—Dry Spiral Mixers 50 to 3000#.
12—Portable Elec. Agitators ¼ to 5 H.P.

MISC. & SPECIAL
Stokes & Kux 2½" single punch preform machines.
Rotary & Single Punch Tablet Machines, ½" to 4".
Belt Conveyors 12', 15' & 20' long.
Anderson & French Oil Expellers.
Gould 75 H.P. Centrifugal Pump 250 PSI.
1—Marco 200 Stainless Steel Homogenizer.
Filling Machines powder, paste & liquid.
1—Howe Mogul Barrel & Bag Packer.
2—Worthington 12" x 12" x 12" Vac. Pumps.
6—Devine Stokes & Buffalo Vac. Pumps.
Soap Machinery for Toilet, Laundry, Chip, Liquid.
Plastic & Rubber Mills, Calendars, Hydr. Presses.
Inject. Mold Equipt. Extruders, Banbury Mixers.

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Whitlock S/S Heat Exchanger; 250 sq. ft. 17" x 10'8".

Whitlock Brine Heat Exchanger; 6 pass; S/S Tubes, 420 sq. ft.; 18" x 12'4".

Frank Eng. S/S 4 pass Condenser; 400 sq. ft.; 26" x 10'8".

Alberger Type 316 S/S 4 pass Condenser; 400 sq. ft.; 28" x 11'6".

Vertical Stainless Condenser; 16" x 11'10" 231 Tubes; 220 sq. ft.

Stainless Heat Exchanger or Calandria; 185 sq. ft. 300 Tubes; 28" x 7'4".

Process Eng. 2 pass Floating Head Heat Exchanger; 500 sq. ft. 24" x 12'.

Ingersoll Rand Disc Flow Vertical Condenser; 18" x 13'; 150 GPM; with Pump.

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1—Stainless Tank #430 Chrome, vert. 7'x10' deep.
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1—Day Mixer steam jacketed, 50 gal. Sigma Blade.
1—Sperry Filter Press 42", open del. 41-plates 1½", 42-frames 1", hyd. closing.
60—New Pressure Cookers, 18"x18" & 24"x28".
1—New Glass Nash Centrifugal Pump, 160 gpm.
1—New Nash Vacuum Pump Type AL-572.
1—Buflovak jacketed Impregnating Tank 42"x52".
1—Stedman Disintegrator size 40-6.
1—Nash Air Compressor, Type AL 623.
1—Manton Gaulin Stainless Homogenizer 125 gph.
1—I&R Vacuum Pump, 5 H.P. 60'.
4—Heat Exchangers, 12" dia. 11' lg., 43 steel tubes.
1—Raymond 8" Hammer Mill, like new.
2—Louisville Steam Tube Dryers 6'x35'.
1—New Louisville Continuous Filtering Machine.
2—Stainless Steel Steam Jacketed Readco Mixers.
1—#316 Stainless Reactor, 265 gals. cap. jacketed.

Abbe Pebble & Tube Mill, 5'x22'—Buhrstone Lined.
1—Patterson Ball Mill, porcelain lined, 17"x27".
1—Patterson Ball Mill. 42x36, jacketed.
2—Large Steam Jacketed Horizontal Mixers.
2—Ribbon Type Mixers, 50 & 90 cu. ft.—like new.
2—Steel Tanks 90,000 gals. ea. vert. welded const.
2—Ball & Jewell #2 Cutters with 75 H.P. Motors.
1—J. H. Day, 3-roll Mill 9x16.
3—3,000 gal. Jacketed Kettles with Turbo Agitators.
1—#10 Day 300 gal. Jacketed Sigma Blade Mixer.
4—New Heat Exc. 60' with Cupro Nickel Tubes.
1—Sparkler Stainless Filter Model 33-S-9.
3—4'x8' Shaker Screens.
6—W & P Mixers, jacketed, heavy duty, sigma blade, 200 gal. with hydraulic dumpers.
3—Baker-Perkins Mixers—same as above.
1—Carver Laboratory Press.
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1—Christie 70"x40' indirect heat Rotary.
3—Link Belt 5'2"x20', 7'5"x25', 11'6"x36' Roto-Louvre.
4—Devine double door Vacuum Shelf 17 and 20—59"x78" shelves.
3—Devine single door Vacuum Shelf 20, 19 and 18—40"x43" shelves.
2—Devine 5'x33', 4'x25' Rotary Vacuums.
1—Devine 5'x10' Rotating Vacuum.
1—Hersey 1½'x12' Rotary, 304 S.S.
3—Louisville Steam Tube 6'x50', 6'x35', 38"x25'.
2—Buflovak Atmospheric double drum 42"x120", variable speed drive.
1—Buflovak 5'x12' Atmospheric single drum.
2—Devine 4'x9' Atmospheric single drum.
4—Tray Dryers, steam heated, 95 sq. ft. tray area.

FILTERS

5—Sparkler 33-S-28, 150 sq. ft., 304 S.S.
2—Oliver Rotary, Monel 8'x10', 3'x2'.
1—Oliver 3' dia. Monel Horizontal.
1—Feinc 5'x3' Rotary Vac, Monel.
1—Feinc 3'x1', Rotary Vac, 316 S.S.
1—Eimco 18"x12", 316 S.S.
2—Sweetland #12, 48 and 32 leaves.
1—Sweetland #7, 20 S.S. covered leaves.
1—Niagara #230-32, 230 sq. ft., 304 S.S.
3—Shriver 30" P&F, 36 chambers, iron.
2—Shriver 30" P&F, 40 chambers, Heresite coated.

CENTRIFUGALS

5—Bird 32"x50" solid bowl Continuous Centrifuges 316 S.S. fume-tight, 60 HP, TEFC motors, NEW 1953.
2—Bird 36"x50", 18"x28" steel, solid bowl, continuous.
2—Bird 24"x38", 18"x28", 316 S.S. solid bowl, continuous.
2—Sharples #C-27, C-20, 316 S.S. Super-D-Hydrators.
1—Sharples PY-14, Super-D-Canter, 304 S.S.
2—Bird 40" suspended, 347 S.S.
1—AT&M 40" suspended, steel.
1—Bird 40" suspended, rubber.
3—Tolhurst 40", 32", 26", suspended.
1—AT&M 40" suspended, steel.
1—AT&M 36" center slung, rubber covered, perforated basket.
1—Tolhurst 32" Suspended, 304 S.S., perforated basket.

EVAPORATORS, REACTORS CONDENSERS, TOWERS, TANKS

1—Artisan 450 sq. ft., 304 S.S., single effect Evaporator, complete with piping, receiver, separator and condenser.
1—Nooter 1000 gal. nickel-clad, jacketed, agitated Reactor.
1—Glascote 500 gal. glass lined, jacketed, agitated Reactor.
2—Pfaudler 250 gal. glass lined, jacketed, agitated Reactors.
3—Pfaudler 500 and 300 gal. glass lined, jacketed Reactors.
2—750 gal., 304 S.S. Kettles with coils and paddle agitators.
1—600 gal., 316 S.S. jacketed, agitated Reactor 200# internal pressure, 75# jacket.
2—500 gal., 347 S.S. jacketed Autoclaves or Reactors, 300# int. pressure, ASME.
3—500 gal., 316 S.S. closed, jacketed Tanks.
4—3000 gal., 304 S.S. jacketed, agitated Tanks.
8—Towers 7'x25'x6", 347 S.S. 6'x63', 6'x24', 5'x96', 30"x70', 24"x42', 12"x30', 8"x30'.
1—10' dia. Hortonsphere, 225 psi.
1—10,000 Aluminum Storage Tank 10'x 16'x½" shell, 25# W.P.
2—Foster Wheeler Karbate Heat Exchangers 188 sq. ft.
1—Struthers-Wells 536 sq. ft., 304 S.S.
2—S.S. Heat Exchangers 1200, 947 sq. ft.
5—1000 gal. S.S. Clad, Vertical Tanks.
1—Langenskamp 6'x5', 316 S.S. Vertical Tank.
2—Langenskamp 600 gal., 304 S.S. agitated Tanks with coils.
1—5'x6" dia. x 16' long, 304 S.S. Horizontal Tank, 3000 gals.
3—Steel Storage Tanks 8½'x25', 8'x16', 6'x20'.
1—Swenson-Walker 30', 304 S.S. Continuous Crystallizer.

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4—Bartlett-Snow direct heat Rotary Dryers 8½'x35', 7'x30', 6½'x30'.
1—Raymond 16' dia. single whizzer Mechanical Air Separator.
3—Tyler Hummer Screens 3'x5' single deck Type 38 with Thermionic Units.
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1—550 Ton Storage Bin.
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1—Dixie #3620 non-clog Hammermill.
4—NEW Jeffrey Hammermills 20"x12", 15"x18".
4—Hardinge Mills 4½'x16', 5'x22", 5'x36", 6'x22", 8'x48".
1—International 6'x7' porcelain lined Pebble Mill, 30 HP motor.
4—Patterson 6'x8', 5'x6', 3'x4' brick lined Pebble Mills.
1—Devine 5'x10' steel jacketed Ball Mill.
2—National 6"x12" Mills.
3—Gayco Air Separators 16', 6', 18".
3—Mikro Pulverizers, Bantam, #1SH #2DH, #2TH.

SCREENS

3—#34 Robinson Triple Deck 30"x104".
6—#21 Rotex single deck 40"x84".
3—#421 Rotex single deck 60"x84".
3—Robinson single deck 40"x84", 304 S.S.
1—Patterson single deck 40"x84", 304 S.S.
2—Tyler Hummer single deck 3'x5', 3'x10'.

MIXERS

1—Baker Perkins #15VUMM, 100 gal. jacketed, 100 HP.
2—Baker Perkins #17DAM, 200 gal. jacketed, Sigma Blades.
1—Baker Perkins 100 gal., 304 S.S., Sigma Blades.
5—Day "Cincinnatus" double arm 250 and 100 gals.
1—Patterson 6' dia. Steel Conical, 15 HP motor.
5—Steel, jacketed, Powder 50, 225 and 350 cu. ft.
1—4' dia., 304 S.S., Conical, 3 HP motor.
1—Eppenbach 1 HP, 304 S.S. Homo Mixer.

MISCELLANEOUS

3—25 Ton Freon Refrigerating Units.
10—Orville Simpson Rotex Sifters 60"x84", 40"x84".
3—Robinson Gyratory Sifters 30"x104", triple deck.
7—Stokes DD2, DS3, D3, B2, "R" & "F" Tablet Presses.
10—Nash Vacuum Pumps H7, H6, H5, L5, H4, TS7, #4, #2, AL-572.
2—Stokes #412G, 412B Vacuum Pumps, motor driven.
15—Chlorimet, Durimet and Duriron Centrifugal Pumps 1½" to 5".

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3500 gallon working capacity Steam Jacketed Double Arm Mixing Tanks.
Day 4000 lb. Jumbo Dry Powder Mixer.
Stokes, Day, New Era, Hottman Mixers, from 2 to 450 gal., with and without Jackets, Single, Double Arm Agitators.
Baker Perkins, Day Readco Heavy Duty, 1 qt. to 160 gals., Double Arm Jacketed Mixers with Sigma or Fish Tail Blades.

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Knapp Wraparound Labeler.
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Resina LC and Elgin Cappers.
Burt 611AUB Wraparound Labeler, to gal.
Pony M, ML, World, Ermold, Pneumatic Semi and Automatic Labelers.
Capem 4-Head Automatic Capper.

FILLERS

MRM and Elgin Rotary Fillers.
S. & S. G1, G2, G6, HG84 Fillers.
MRM S. A. Stainless Steel Vacuum Fillers.
Triangle Elec-Tri-Pak Fillers, 1 to 6 Head.
Elgin 5-Head, Hope 1, Filler 2 and 4-Head Stainless Steel Piston Fillers.

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Fitzpatrick Model D Stainless Steel Comminuter.
Mikro 4TH, 3TH, 3W, 2TH, 1SH Pulverizers: Schutz O'Neill Mills.
Charlotte #3 Colloid Mill.
Day, Robinson, Tyler Hum-mer, Great Western, Gayco, Raymond Sifters.
Rotex Sifters—40½" x 120" and 40" x 84".

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BP SS 100 gal. Mixer, Sigma Arms, 20 HP, Exp. Pf.
Pfaudler glass lined Jacketed Still, 42"x44"
3 Read 18"x48" Vibrating Sifters
Hercules 200 sq. ft. SS Pressure Filter
Mikro Mill #2SI, serial #5403, extra head
Pfaudler glass lined Tank, 15 gallons, closed top
Ross 40 gal. Pony Mixer, direct drive, 3 H.P.
Gen. American 42"x120" Twin Drum Dryer
AT&M 3'x6' Vertical Heavy Duty Mixers
2 W & P Heavy Duty Jktd. Mixers, 15 gal. 15 HP
Roto Lauvre SS 5'x20' Rotary Dryer, complete.
Stokes 5'x10' Rotary 316 SS Vacuum Dryer
Nash Hytor Vac. Pump #6, with 40 HP motor

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138 CFM	100 PSI	7x7 Ing. ESI
234 CFM	100 PSI	9x9 Worth. HB
268 CFM	500 PSI	10-4½x10 Ing. XOB
368 CFM	100 PSI	12x10 Ing.—Penn
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465 CFM	100 PSI	12x11 Worth. HB
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1—AT&M Susp. 48" dia. Perf. Basket, St. St., Fume tight
2—Fletcher Susp. 40" dia. Basket, 1 perf. plain steel, 1 rubber covered imperf.
3—Bird 24" x 24" Horiz. Centrifugal Screen Filters, Monel
1—Bird 24 x 38 monel, Solid Bowl
3—Bird 32 x 50 Solid Bowl Centrifugals, Type 316 Stainless Steel, fume-tight. 60 HP motor. Built 1953
1—Bird 36" x 50" Solid Bowl, Steel
1—Bird 40" x 60" Solid Bowl, T304 S.S.
4—DeLaval Nos. 74-11; 94-01; 600
2—DeLaval #BUH-3930 Hermetic Clarifiers, Stainless Steel
2—Sharples Super-D-Hydrators, C-20 & C-27, Stainless Steel T316

DRYERS

3—All stainless steel Vacuum Shelf Dryers, 108 sq. ft.
1—Devine #27 Vacuum Shelf, 475 sq. ft.
1—Devine #23 Vacuum Shelf, 356 sq. ft.
2—Devine Vacuum Shelf Dryers, size 17, 80 sq. ft. UNUSED.
1—St. St. Spray Dryer, 19' dia. x 20' high, with Western Precip. nozzles, fans, oil burners, etc.
1—Bowen St. St. Laboratory Spray Dryer
1—American Double Drum Vacuum Dryer, 36" x 84"
7—Double Drum Dryers; 42" x 120"; 42" x 100"; 32" x 52"; 24" x 60"; 22" x 38"
4—Rotary Hot Air Dryers: 4'6" x 40'; 4'6" x 32'; 3'6" x 25'; 3 x 24'
3—Rotary Coolers: 104" x 30'; 104" x 70'; 5' x 40'
1—B & S Rotary Hot Air Dryer, 3' x 15', Everdur (Silicon Bronze)
2—Stokes Jacketed Rotary Vacuum Dryer 3' x 10', 3' x 15'
2—Rotary Steam Tube Dryers: Louisville 6' x 30' and Ruggles Cole 4' x 30'
2—Davenport size 2A Dewatering Presses
2—Swensen Walker Crystallizers steel, jacketed, each 30' long

EVAPORATORS—STILLS

1—Ozark-Mahoning Submerged Combustion Evaporator, type 316 stainless steel, 2,800,000 BTU/Hr.
2—Bartlett Snow St. St. Jacketed Evaporating Kettles 6' dia. x 3' deep with heavy duty agitator and 25 HP 4-speed drive
1—Conkey 1900 sq. ft. Triple Effect, Evaporator Vertical long Herculoy tubes
1—Buflovak size 6.5 model 629D Double Effect, all stainless steel, 588 sq. ft.
3—Sainless Steel Dairy type 6' dia. Vacuum Pans with coils
1—Struthers-Wells Single Eff. St. St. 625 sq. ft. vertical tubes
1—Stainless Steel 145 sq. ft. coil, 500 gal.
2—150 gal. Jacketed Vacuum Pans or Still 1—St. St., 1—Monel
1—Stokes type 316 St. St. Double effect water still, 250 GPH
8—Copper Bubble Cap Distillation Columns 24" dia. to 48" dia.
4—Stainless Steel Packed type Columns 8" dia. to 24' dia.

AUTOCLAVES—REACTORS

6—465 gal. St. St. 3' dia. 8'6" deep, 150# WP, 165# jkt. pr.
1—1420 gal. St. St., 4' dia. x 15' deep, 200# WP, 85# jkt. pr.
3—Pfaudler Glass Lined, jktd. & agit. 30 gal., 50 gal. & 100 gal.
3—St. St. T347 13 gal. 1400# test, 50# jkt.

FILTERS

1—Niagara Model 510-28-type 316 Stainless Steel Filter, 510 sq. ft.
2—Sparkler #33-S-28 Filters, Steel Tank, St. St. plates
1—Feinc 6'6" D x 6' Face String Discharge
2—Eimco 10' x 12' Rubber Covered Filter
2—Sweetland Filters: #12 (12 lvs.); #5 (20 lvs.)
5—Cast Iron Filter Presses, 30" x 30" open delivery, 28, 35, and 50 chambers
5—Filter Presses, closed delivery, 7"—36"

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MIXERS—BLENDERS

1—Gemco St. St. 30 cu. ft., 54" dia., Jktd. Conical Blender
1—Conical Blender, Steel, 6' dia.
3—Sprout Waldron size 12 Ribbon Mixers, 336 cu. ft. work. cap.
5—Stainless Steel Sigma Blade double arm jacketed mixers, 30 gal. 5 gal., 10 gal., 50 gal. & 75 gal.
3—Sigma Blade Double Arm Jacketed Mixers, 2¼ gal., 50 gal. & 100 gal. work. cap.
2—Side Entering Stainless Steel Mixers, 15 HP & 25 HP
3—Falk Vertical Agitator Drives #10-GDX, 10:1 300 HP—UNUSED
5—Turbo Vertical Drives, #5B, 5:1, 40 HP

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Chemical—Process—Paper

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Chemical Engineering

Reader Service

MAY 1957

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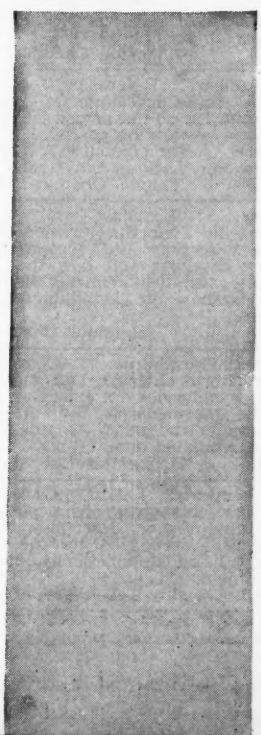

GUIDE TO TECHNICAL LITERATURE

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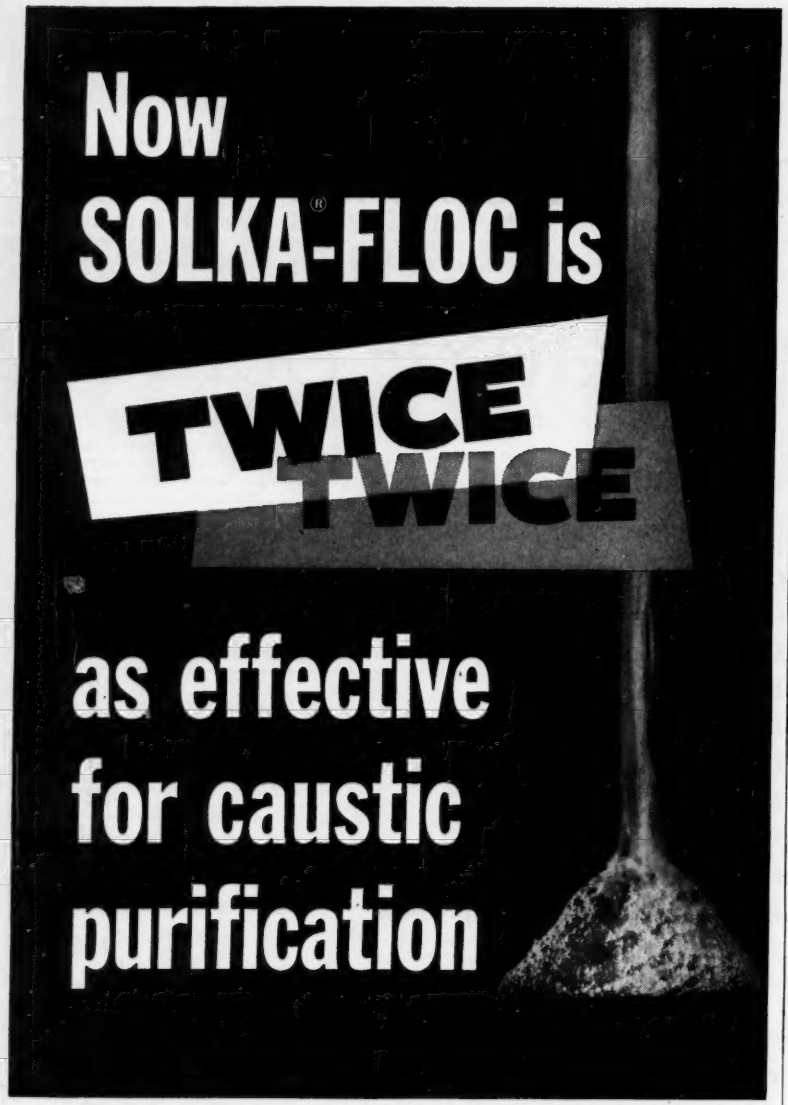

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. . . and the only adsorbent that also functions as a superior filter aid

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SOLKA-FLOC comes in a wide range of grades for your specific needs. For samples and more information, write Dept. FD-5, our Boston office. A representative will gladly call.

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Berlin and Gorham, N. H.; Corvallis, Ore.

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Chemicals

Acid, Levulinic.....New versatile raw material now available in ton quantities. Unusual in that each of its three methylene groups is situated next to a carbonyl group is situated tails available in bulletin.
217 *Quaker Oats Co.

Acids, Fatty.....These fatty acids are readily available from the El Dorado Div.—caprylic, eldhyco. capric, lauric, coconut, palmitic and myristic. Company makes details available and offers samples.
460a *Foremost Food & Chem.

Acrylic Emulsions.....“Rhoplex Acrylic Emulsions in Paper Coatings” is the title of a new, 20 p. booklet containing information on characteristics of acrylic emulsions; properties of pigmented coatings.
420A Rohm & Haas Co.

Aluminum Isopropoxide.....4 p. data sheet covers physical properties, specifications, packaging and shipping. Describes its use in organic synthesis, the plastics and paint industries.
420B Anderson Chemical Co.

Butyl Rubber.....New portfolio on butyl rubber developments. Latest information on markets, a technical bulletin evaluation of butyl accelerators (sulfur type cures); a study of carbon black in butyl rubber
420C Thiokol Chemical Corp.

Catalysts.....“Harshaw Catalysts . . . Made to Your Specifications” includes sections on: typical Harshaw catalysts and how they are used; catalytic chemicals supplied by Harshaw, etc. Available on request.
112 *Harshaw Chem. Co.

Chlorides, Phosphorus.....Company's phosphorus chlorides and phosphorus oxychlorides are extremely versatile intermediates; they are high in quality and purity. Complete details available upon request.
364c *Hooker Electrochem. Co.

Coal Chemicals.....The 1957 edition of this company's chemical index contains a short description of all chemicals produced by the company, listed alphabetically and according to classes.
421A Reilly Tar & Chem. Corp.

* From advertisement, this issue

LITERATURE

C. J. ROHRBACH

Corn Products.....The advantages of using a new corn adjunct concentrate to replace dry cereal adjuncts in the brewing of beer are detailed in a new booklet of 8 p. Outines suggested methods of use.
421B Corn Products Sales Co.

Defoamers.....2 p. bulletin describes new liquid defoamer and its application in latex paints, coating and resin sizing of papers, textile sizing, metal cleansers, starch and protein adhesives.
421C Air Reduction Chem. Co.

Defoamers, Silicon.....Dow Corning "Antifoam B" disperses immediately in aqueous solutions. No stirring or agitation required. Ready to use & ideal for continuous processing. Particulars and free sample.
93 *Dow Corning Corp.

Diisocyanate.....6 p. of detailed data on dimethyldiphenylmethane. Covers structural formula, analysis, properties and suggested uses. Includes infrared spectrogram, vapor pressure curve.
421D Allied Chem. & Dye Corp.

Elastomers.....Neoprene and Hypalon elastomers are used in improving products and cutting maintenance and replacement costs. Full details available in publication. "The Du Pont Elastomers."
101 *E I du Pont de Nemours.

Epoxy Potting Compounds.....3 p. technical bulletin covers a new series of epoxy potting compounds. Time-viscosity curves, comparative table of electrical, mechanical and physical properties.
421E Houghton Laboratories Inc.

Esters, Methyl.....These methyl esters are readily available from the El Dorado Div.—caprylate, Eldo 18, caprate, laurate, coconate, myristate, caproate, palmitate. Details available and samples offered.
L406b *Foremost Food & Chem.

* From advertisement, this issue

Contents of this issue . . .

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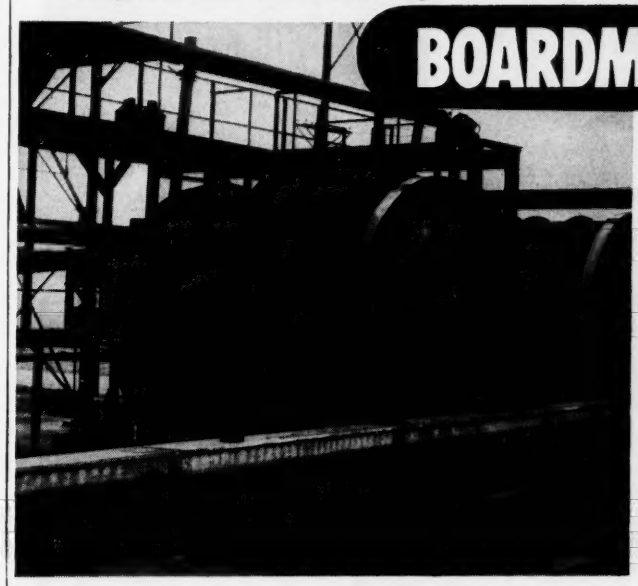
Pelletizing Drums for the Process Industries ★

designed and fabricated by

BOARDMAN



*At Sunray, Texas, Continental Blacks, Inc. operates these two drums to pelletize carbon for packaging. BOARDMAN designed and fabricated this equipment to the customer's exact specifications. These drums play a big part in producing for Continental a uniformly-granulated product with a minimum of dust separation.

This metal fabrication "know-how" can be applied to a variety of metals, including stainless steel, carbon steel, clad steels, wrought iron and aluminum. Whatever the type metal, BOARDMAN facilities are ready to serve you.

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BRANCH OFFICE: TULSA, OKLAHOMA

DAY "AC" Dust Filter and DAY Dual-Clone in the Stauffer Chemical Company fertilizer plant located in Tacoma, Washington

THIS DAY DUST CONTROL EQUIPMENT CERTAINLY SOLVED OUR DUST PROBLEM!

DAY Supplies Dust Control Equipment for Practically Any Industrial Need

The DAY "AC" dust filter* (shown above) captures submicron particles with 99.99+% filtering efficiency. This filter is used in many plants throughout the United States and Canada and handles a wide variety of materials including aluminum, cement, chemical, food, pharmaceutical, porcelain, radioactive, rubber and many other dusts.

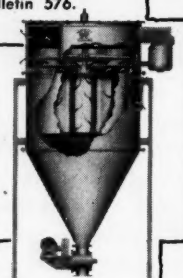
The DAY Dual-Clone (above-right) has low horsepower requirements and operates with unusually low back pressure. It requires no maintenance.

For latest information about DAY "AC" and Dual-Clone equipment write toDAY for Bulletins 559 and 49-DC.

*Licensed by H. J. Hersey, Jr.

DAY TYPE "HV" CYCLONIC SEPARATOR

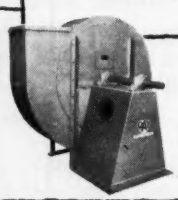
A heavy gauge, welded, high efficiency cyclonic separator. The DAY "HV" has a wide range of applications. It handles abrasive or high temperature dust laden air and requires no maintenance because it has no moving parts. Available for pressure or vacuum operation. For additional information write for Bulletin 576.



DAY TYPE "RJ" DUST FILTER*

A packaged dust filter shipped completely assembled and ready to run. Provides high performance, top efficiency dust control at low cost. High air-to-cloth ratios give extra air handling capacity in small area. Furnished with or without dust fan and discharge equipment. For latest information write toDAY for Bulletin 560.

*Hersey and DAY patents applied for.



DAY TYPE "G" EXHAUST FANS

High air delivery per horsepower required. These fans are designed specifically for dust control applications. Each fan is statically and dynamically balanced before shipment. For further information write toDAY for Bulletin 471.

DAY SINCE 1881

The DAY Company

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P.O. Box 70N, Fort William, Ontario.

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STOP AIR POLLUTION with DAY DUST CONTROL

LITERATURE . . .

Fertilizer.....“Chemical Fertilizers for Canada’s West”, new 16 p. brochure describes the engineering and construction of Northwest Nitro-Chemicals Co. Ltd.’s new fertilizer plant in Medicine Hat, Alberta.
422A M. W. Kellogg Co.

Furfural.....Furfural: selective solvent for refining petroleum fractions and rosins; extractive distillation agent for hydrocarbon separations; reactive solvent for many resins. See Bulletin No. 204.
342 *Quaker Oats Co.

Glycol Solutions.....Use of glycol solutions in steam-set printing inks is described in a new technical bulletin. Details the principle of steam setting and water tolerance, properties of glycol solutions.
422B Archer-Daniels-Midland Co.

Hexachlorophene.....Supplement to Technical Bulletin H-1 entitled “G-11 (Hexachlorophene USP) An Annotated Bibliography” includes abstracts of 28 recent articles and one patent.
422C Sindar Corp.

Hydrocolloids.....8 p. about Irish Moss and its extractives. Information on these hydrocolloids includes: what they are, what they can do for you, listing of properties like water viscosity.
422D Seaplant Corp.

Latex Paint.....“Studies on the Influence of Wet Ground Mica on the Adhesion Characteristics of Latex Paint”, Technical Bulletin No. 28, makes tabular comparisons of performance of plants.
422E Wet Ground Mica Assn.

Paint.....8 p. bulletin G-16 covers polyvinyl latices for paint formulations. It describes physical properties of a new latex, this company’s Geon 450 X3 which promises to expand latex paint use.
422F B. F. Goodrich Chemical Co.

Peracetic Acid.....How peracetic acid is used in an aerosol spray to sterilize apparatus, instruments, gloves and whole laboratory areas. New 8 p. Bulletin 83 discusses development of the spray, performance.
422G Becco Chem. Div.

Petroleum Products.....Called “Petro-Engineering Service”, new 24 p. booklet describes company’s cost-free service providing practical assistance on problems involving fuels, lubricants.
422H Gulf Oil Corp.

Petroleum Products.....“Maintaining the Quality of Petroleum Products,” Bulletin MQ-215, contains 64 p. on handling and storage of petroleum products, prevention and removal of contamination.
422I Standard Oil Co.

Polyethylene.....16 p. booklet describes company’s new rigid polyethylene made by low-pressure methods. Basic chemistry, applications, properties, costs. Also outlines service facilities.
422J W. R. Grace & Co.

Polymers, Block.....Some characteristics of the many Pluronic grades: defoaming, dispersing and suspending, sequestering, wetting and penetrating, lubricating, dedusting, free rinsing, etc. Grid data.
174-5 *Wyandotte Chem. Corp.

* From advertisement, this issue

Polyphenyl, Chlorinated.....Aroclor 1248 is a highly stable chlorinated polyphenyl; does not support combustion up to its boiling range 652° to 725°F.; is non-corrosive. Request technical information.
135a *Monsanto Chem. Co.

Polystyrene.....New polystyrene molding compound, specifically for producing thin walled articles with improved resistance to breakage, is described in molding materials release 23. 6 p.
423A Bakelite Co.

Polyvinyl Acetate.....Suggested paint formulations with polyvinyl acetate emulsion is the subject of the new 7 p. technical bulletin PVB-521A. For each formulation covered, tabular property data is provided.
423B Colton Chemical Co.

Polyvinyl Materials.....Summary of the properties and fields of application of the company's polyvinyl resins, plastics, latices and polyblends. Sections on calendering and coating, extrusions, foam and sponge.
9 B. F. Goodrich Chem. Co.

Potassium Silicate.....Cowles potassium silicate blends readily with other water-soluble and water-dispersible binders, adhesives and coatings. Gives better adhesion in water paints. Request Bulletins.
B455 *Cowles Chemical Co.

Pyrethrum.....“Pyrethrum Facts for 1957” covers African pyrethrum produced from daisy-like flowers. Properties, applications and production figures are given for the product.
423C African Pyrethrum Dev. Inc.

Resins, Epoxy.....Method of protecting eroded concrete is described in nine steps on a new 2 p. flyer. Also included is listing of cost, maintenance benefits to be derived from the use of epoxy systems.
423D Furane Plastics Inc.

Resins, Tetrafluoroethylene.....Teflon tetrafluoroethylene resins used extensively in process industries. Offer chemical inertness, high heat resistance, low-temperature toughness. Properties & applications.
59 *E. I. du Pont de Nemours.

Silicone Rubber ..... 45 p. booklet called “1957—Silicone Rubber” is a basic up-to-date report on silicone rubber available. Discusses basic chemistry, properties and compromises in compounding.
423E Connecticut Hard Rubber Co.

* From advertisement, this issue

Any bulletin or catalog . . . yours for the asking

You can get any publication in this literature listing by circling its key number on the Reader Service Post Card (inside back cover). Replies will reach you direct from the manufacturers.

How a Paracoil OBSTACLE COURSE gives you better heat exchange

Davis Makes It — Better!

Paracoil Type “P” Exchanger, 2-Pass Type, Stationary Head End. Tube bundle partially withdrawn, showing segmental baffles. Note close tolerances between tubes and baffles, and between baffles and shell. Close baffle tolerances assure higher heat transfer rates.

Tumble the liquid . . . keep it baffled . . . make it take the long way home . . . that's what Davis will do to create proper turbulence to give you the most efficient heat transfer in equipment designed for your needs. And, we know just how to do it.

Our engineers have been designing equipment for chemical process industries, industrial process application, power plants, utilities and marine projects since 1915.

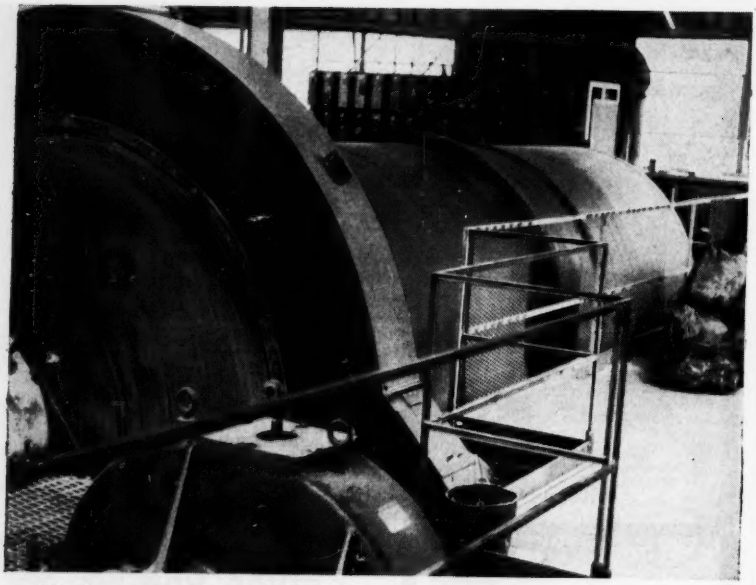
Write for Bulletin 1000

DAVIS ENGINEERING CORPORATION

30 Rockefeller Plaza, New York 20, New York Circle 6-5650

1064 East Grand Street, Elizabeth 4, New Jersey ELizabeth 2-6780

XUM



Hardinge 9′ x 22′ Pebble Tube Mill in an Ohio plant producing silica flour.

Hardinge TUBE MILLS...

... for wet grinding

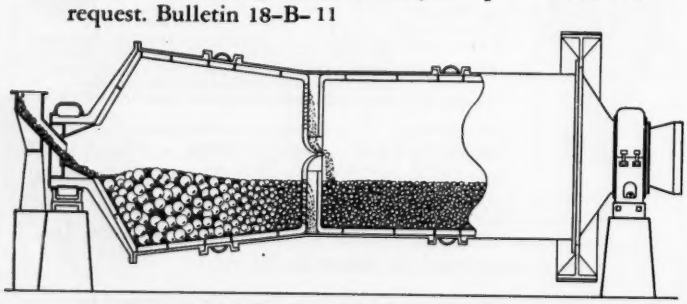
(in water or acid pulps)

Titanium Pigments
Manganese Dioxide
Diatomaceous Earth
Limestone

... for *dry* grinding

Fillers
Silica Flour
Gypsum
Carbon Black
Pigments
Cement materials

Regardless of the requirements, Hardinge Tube Mills are designed to meet specific needs. Available from 2 to 10 feet in diameter; 6 to 35 feet in length; single or multiple compartments; with acid proof lining of rubber, silica and porcelain. Complete specifications on request. Bulletin 18–B– 11



Tricône compartment Tube Mill with grate and lifters.

HARDINGE
COMPANY, INCORPORATED

YORK, PENNSYLVANIA • 240 Arch St. • Main Office and Works

New York • Toronto • Chicago • Hibbing • Houston • Salt Lake City • San Francisco

LITERATURE . . .

Silicones.....Benefits provided by silicone masonry water repellents and specifications for applying them are described in a new brochure, "Silicone Masonry Water Repellents", designated CDS-81.
424A General Electric Co.

Soda, Caustic.....Company offers Caustic Soda Engineering and Handling Guide, Bulletin 102; Caustic Soda Buyer's Guide, Bulletin 101 and technical data sheet. Company makes all available upon request.
364a *Hooker Electrochem. Co.

Solvents, Chlorinated.....Company offers five chlorinated solvents: ortho-Dichlorobenzene, Monochlorobenzene, Monochlorotoluene, Trichlorotoluene, Trichlorobenzene, Trichlorethylene. Information.
364b *Hooker Electrochem. Co.

Urethane Foams.....14 p. booklet called "A Vast New World of Industrial and Business Opportunities" covers history, chemistry, manufacture, fabrication, and research on urethane foam.
424B Dayton Rubber Co.

Urethane Polymers.....Combination catalog and file folder on foamed-in-place flexible, semi-rigid and rigid urethane plastic polymers. Covers in-plant applicatiions, electrical properties.
424C Dayton Rubber Co.

Water.....Nation-wide water supply problems, particularly the need for bigger municipal water and sewage facilities, are discussed in a new booklet entitled "Your 1,100 Gallons."
424D Fairbanks-Morse & Co.

Construction Materials

Alloys, Brazing.....How Nicrobraz alloys are used to join stainless steels and special alloys is discussed in new Catalog, Form SD-23. All Nicrobraz alloys resist tremendous heat and corrosion.
424E Wall Colmonoy Corp.

Alloys, Corrosion-Resistant.....Have excellent resistance to hot mineral acids, strongly oxidizing salts, powerful gaseous oxidants, and combinations of these media. "Hastelloy Corrosion-Resistant Alloys."
299 *Haynes Stellite Co.

Aluminum Corrosion.....How you can determine the corrosion resistance of aluminum when designing process plants and equipment is discussed in brochure entitled "Corrosion Keys to Aluminum."
424F Reynolds Metals Co.

Coatings.....Leaflet describes this company's surfacing material for redoing or patching concrete floors. Describes proper method of application for the chemical-resistant material.
424G Stonhard Co.

Coatings.....Leaflet explains how to restore and preserve your roof with company's plastic and liquid roof resurfacers. Discusses properties and performance of the resurfacer under different use conditions.
424H Stonhard Co.

* From advertisement, this issue

XUM

Coatings, Protective.....Catalog describes Amercoat protective coating systems for corrosion control. Outlines corrosion control services: assistance in selection, help write specifications, etc.
305 *Amercoat Corp.

Coatings, Protective.....25 p. catalog on this company's Polyken coating for protection of underground pipelines, and in above ground installations where corrosive agents are a threat to machinery.
425A Kendall Co.

Coatings, Protective.....Brochure 1-7 discusses application of protective coatings and linings together with data on sand and grit blasting, fabrication and repair of process equipment.
425B Metalweld, Inc.

Fabrication, Process Equipment..... Company's "know-how" assures you of a high-quality product at minimum cost whether your needs require fabrication from stainless steels, aluminum, etc. Booklet.
63 *Chicago Steel Tank Co.

Fabrication, Stainless Steel.....Control of these factors: selection of best process, prevention of distortion and warpage, restriction or removal of discoloration, etc. "Sheet and Plate Fabrication."
445 *Kirk & Blum Mfg. Co.

Grating and Treads.....In Bulletin 2527 you will find descriptions and illustrations on electroforged, riveted, rectangular, diagonal, "U" type and "T" interlocked gratings and treads.
425C Blaw-Knox Co.

Insulations, Industrial.....No matter where your insulation job may be —Armstrong can give you efficient, well-integrated service from original specs to final installations. Booklets describe full line.
95 *Armstrong Cork Co.

Laminates, Low Pressure.....Bulletin covers low pressure laminates for corrosion resistance, electrical insulation, high strength and unlimited shapes. Company offers further information.
425D Carl N. Beetle Plastics.

Linings & Coatings, Protective..... What are the types of protective linings and coatings, why are they important, when and how should they be applied? Answers are found in a new report.
425E Metalweld, Inc.

Maintenance Materials.....Descriptive folder for plant engineers and maintenance men covers wide range of industrial maintenance problems. Covers undercoats, sealers, cements, roofing comp'ds.
425F Borden Co.

Maintenance Products.....Complete Skyco line of industrial maintenance products is described in a new catalog now available. Includes cleaning and coating materials used in plants.
425G Skybryte Co.

Membrane, Waterproofing.....According to a new brochure, Glasfab membrane of fiber glass yarn used with waterproofing compounds assure lasting results for below-grade waterproofing of walls.
425H Twinsburg-Miller Corp.

* From advertisement, this issue

THIS METHOD BEATS HAND BOLTING 35 TO 10

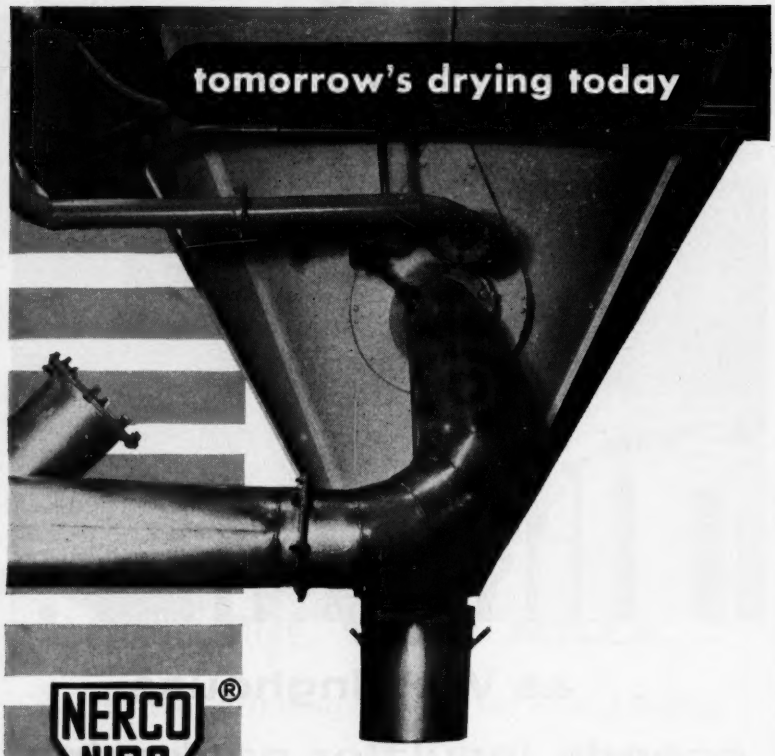
...as Westinghouse speeds insulator packaging with Snap-on impact wrench

Clark Moore, *Snap-on* sales engineer, and Westinghouse manufacturing engineers developed the use of this electric impact wrench on the new packing line for crating apparatus insulators at the Westinghouse Electric Corporation plant at Derry, Pa. The impact wrench has speeded the operation by tightening 35 bolts in the time required to tighten 10 by hand. Officials of Westinghouse state that this *Snap-on* tool pays for itself every ninety days in time saved.

This is another example of how the combination of a *Snap-on* sales engineer's training and experience, plus special *Snap-on* tool equipment, helped a manufacturer save money. If you have a tool problem, get in touch with the nearest *Snap-on* branch or write us. We will arrange to have our representative call on you and render all possible assistance.

*Snap-on is the trademark of Snap-on Tools Corporation.

SNAP-ON TOOLS CORPORATION
8106-E 28th Avenue • Kenosha, Wisconsin



NERCO NIRO®

. . . . spray dryers

Nerco-Niro, the advanced spray drying system, sets the pace in design and drying performance for today's—and tomorrow's—processing requirements. You can dry more, in less time, with closer product control, in a Nerco-Niro system.

No hot metal surfaces to injure heat-sensitive materials.

No scrubbers or scrapers necessary—product is free-flowing.

Uniform bulk density and particle size.

Hourly power consumption per ton of product as low as 20 H. P.

Write for
Bulletin No. 226

Nichols Engineering & Research Corp.
Nerco-Niro Spray Dryer Division
70 PINE ST., NEW YORK 5, N. Y.
1637 N. Illinois St., Indianapolis 2, Ind.
1477 Sherbrooke St. W., Montreal 25, Canada

LITERATURE . . .

Mortar, Non-Shrink.....How to get better results in 12 important construction operations by using non-shrink mortar is discussed in new Bulletin E-38. Illustrations keyed to explanatory paragraphs.
426A Master Builders Co.

Plastic Coater.....Newly designed and enlarged section of general catalog covers dual-purpose thermoplastic spray and fluidizing unit, the laboratory powder fluidizer and plastic components.
426B American Agile Corp.

Plastics, Polyvinyl Chloride.....Bulletin 80-3 tells all about this amazingly versatile material and its applications, Ryertex-Omicron PVC resists attack of more than 250 corrosive solutions and gases.
275 *Joseph T. Ryerson & Son.

Rubber & Plastic Materials.....Piping pumps, valves and tanks have a wide range of temperatures, pressure, impact resistance. For details about Ace rubber and plastic materials, request Data CE-50.
322e *American Hard Rubber Co.

Steel, Plastic.....Devcon, the plastic steel, for making jigs, molds, models, fixtures, forming dies, rebuilding machinery, salvaging metal parts, plumbing-automotive repairs. Bulletin N1-100.
426C Devcon Corp.

Steels.....Included in the new 232-page "Product & Warehouse Catalog" are 16 categories of special purpose steels with over 20 estimating, conversion and weight tables useful to steel users.
426D Crucible Steel Co.

Steels, Clad.....One side corrosion resistant nickel or high alloy; the other rugged, economical carbon or alloy steel. Permanent bond produced by heat and pressure on rolling mills. "Clad Steel Equipment."
225a *Lukens Steel Co.

Steels, Rubber-Lined.....Ace rubber-lined steel . . . strength and pressures of steel plus chemical resistance of hard rubber. Excellent for alkalis, most inorganic acids, etc. Full details in Bulletin CE-52.
323c *American Hard Rubber Co.

Steels, Stainless.....Company offers informative 44 p. booklet, "Making the most of Stainless Steels in the Chemical Processing Industries." Dozens of Crucible stainless grades are available to you.
293 *Crucible Steel Co. of America.

* From advertisement, this issue

For the latest developments in
Chemicals
Equipment
Processes
you'll find our "Guide To Technical Literature" right up your alley. You can get any bulletin or catalog in this listing . . . and fast. Simply circle the item's number on the Reader Service Post Card and mail.

Tantalum.....Company offers a corrosion test kit, available without charge to research technicians. Contains tantalum sheet. Also offers publication, "Corrosionomics," containing articles on tantalum.
440 *Fansteel Metallurgical Corp.

Teflon.....Varied mechanical properties cited in Bulletin T-300 show how heavy walled tubing and rod can be used as gaskets, pump and valve parts. Continuous rating from —265 to 500 F.
427A Haveg Industries.

Electrical & Mechanical

Batteries, Industrial....."So You're Going to Buy an Industrial Battery" helps you select the most economical battery for your application. Four-point program covers all aspects of selection and use.
427B Gould-National Batteries.

Casters & Wheels.....Featuring Darnelloprene treads (a soft resilient Neoprene rubber compound) . . . casters offer ease of movement, quietness, and protection for floors. Details available in Manual.
R458 Darnell Corp.

Connectors & Panels.....Panels provide flexible, centralized control in transferring any number of thermocouples. Connectors permit fast, easy making and breaking of thermocouple circuits. Bulletin 23-E.
B461 *Thermo Electric Co.

Drive, Conveyor . . . . . Selection of drives for screw conveyors is a simple matter with new Catalog SCD-57. A complete shaft-mounted Screw-King drive can be designed within a few minutes.
427C American Pulley Co.

Drives, Belt.....A completely new 112-page engineering Data book is available for the selection and design of Poly-V belt drives. Many useful charts, tables and diagrams together with specifications.
427D Raybestos-Manhattan.

Drives, Worm Gear.....Cleveland Worm Gearing affords advantages for practically any power job. Steel worm on bronze gear reduces motor speed evenly, efficiently, and quietly. Request Catalog 400.
12 *Cleveland Worm & Gear Co.

Ejectors.....Engineering data covers the complete range of Elliott steam jet ejectors including single-stage, special corrosion-resisting, and various multi-stage types. Available on request.
92 *Elliott Co.

Electric Hoists.....Operating features and specifications of new LeTourneau hoists are listed in Bulletin 401-S1. In 3 to 15 ton capacities, units take 37% less head room, control to 0.008 in.
427E R. G. LeTourneau, Inc.

Electrical Connectors.....Bulletin P 3157-5 explains how Saf-T-Arc receptacles, plugs and connectors assure complete safety, even under overload. Made of cast aluminum housings and enclosures.
427F Russell & Stoll Co.

* From advertisement, this issue

*FIRST LINE *Extended-Surface* HEAT EXCHANGERS

ASK THE AEROFIN MAN

Specify Aerofin and you specify high efficiency, long service life and low maintenance and service costs.

Take advantage of Aerofin's unequalled experience, production facilities, and materials-testing and design research — of Aerofin's complete engineering service at the plant and in the field.

* *Aerofin makes extended heat surface exclusively — not as a by-product, not as a side-line.*

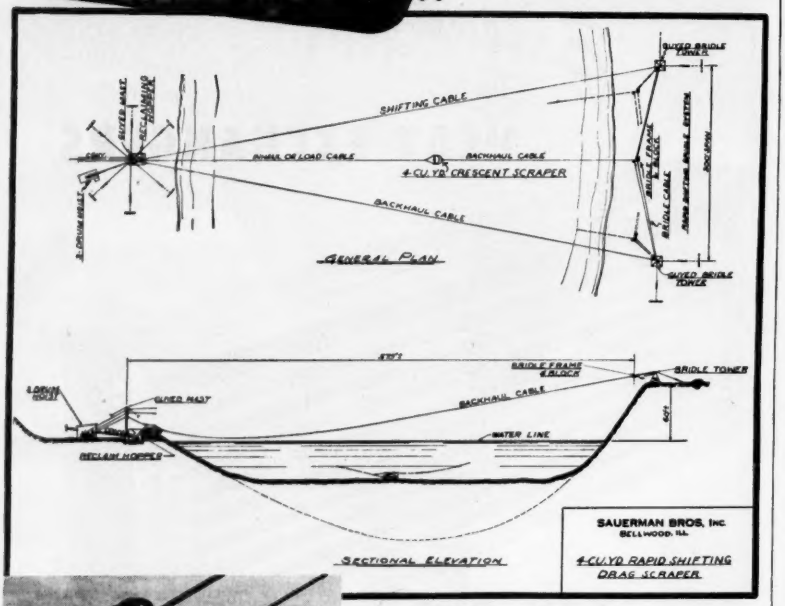
Throughout the Chemical Industry —
Aerofin units do the job Better, Faster, Cheaper

AEROFIN CORPORATION 101 Greenway Ave Syracuse 1, N. Y.

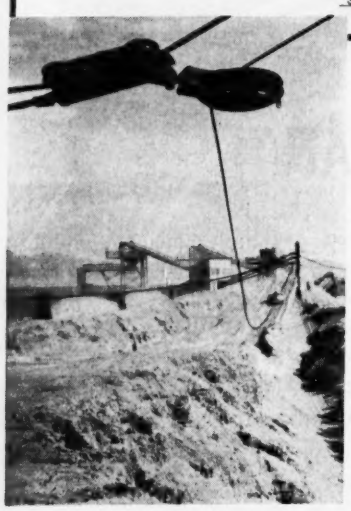
Aerofin is sold only by manufacturers of fan-system apparatus. List on request.

the SAUERMAN METHOD....

Scraper Machines Engineered to Your Operation



Above drawing was prepared for a specific drag scraper installation and does not represent maximum spans.



View shows rapid shifting bridle frame and all operating cables. Crescent may be seen in background conveying load to reclaiming hopper just in front of mast.

•

Contact Sauerman's engineering department for specific recommendations and information. No obligation.

Ask for Catalog A, Drag Scrapers—24 pages of job photos and specifications. Request Field Reports showing your material being handled by the low cost Sauerman Method.

The Sauerman Method works equally well over widely differing areas and span limits . . . on hills, swampy ground or underwater . . . handles any material a dragline can dig.

Every scraper machine is powered by a Sauerman Roller Bearing Hoist, especially designed to withstand sudden shocks and changes in speed.

When a rapid shifter is used, a third hoist drum is added to shift the bridle frame. The rapid-shifting bridle system (upper right of drawing) permits frequent shifting of the scraper's line of operation in non-caving material, shallow excavations or overburden.

Operating costs are lower—basically, it is cheaper to drag material than it is to lift and transport it. You eliminate the power costs of moving heavy machinery about the area. You pay only for pay loads—not dead weight. When expendable parts—sheaves, clutch or brake linings—are replaced, the machine is restored to practically new condition.

Sauerman can help you select the method of materials handling most profitable for your job—a system that will give you the lowest cost per cu. yd. handled.

SAUERMAN BROS. INC.

642 S. 28th AVE. | BELLWOOD, ILL.

Crescent Scrapers • Slackline and Tautline Cableways • Durolite Blocks

LITERATURE . . .

Feeder, Gravimetric Belt.....Features of the new Hi-Weigh Model 37-20 feeder are listed in new Bulletin 35-N62. Covers unique Sens-A-Gram controller and gives specifications.
428A Omega Machine Co.

Grating, Steel.....Rigid, one-piece construction. Choice of cross bar and bearing bar designs and spacings affords maximum safety under all working conditions. Complete details available in Catalog 2527.
74 *Blaw-Knox Co.

Illuminators, Gage.....Jerguson gage illuminator gives up to 3 times the illumination . . . lights entire gage glass, no glare or blind spots, low cost lighting, explosion-proof. Full details in Data Unit.
R456 *Jerguson Gage & Valve Co.

Motor Units.....Rugged in construction and simple in design, Chapman Motor Units insure longer life with fewer repairs. Smooth, accurate and trouble free operation. For details, request Catalog 51.
120 *Chapman Valve Mfg. Co.

Motors.....New Elliott C-W type N motors are designed for the utmost in dependability. They will withstand physical abuse. For complete information on performance and features, request Bulletin PB 6000-6.
295 *Elliott Co.

Motors.....Features: good enclosure, copper and iron, the best bearing lubrication system, tough, resistant insulation. Add up to designed durability. Full information available in Bulletin No. B-2504.
212-3 *Reliance Elec. & Engrg.

Motors.....Wagner Type EP Motors are fully protected against corrosive fumes and liquids, dust, dirt and moisture. Protection assured by totally enclosed, fan-cooled construction. Bulletin MU-203.
218 *Wagner Electric Co.

Motors, Chemical.....New motor specifically designed and constructed to withstand corrosive conditions encountered in chemical plants, oil refineries, sulphur plants, etc. See Bulletin 1050.
428B Louis Allis Co.

Motors, Fan-Cooled.....Six basic advantages of Robbins & Myers new line of re-rated fan-cooled motors are explained in Bulletin 500-A. Motors are available in ratings from ½ to 40 hp.
428C Robbins & Myers.

Motors, Gear.....Louis Allis gearmotors are compact, efficient, long life, dependable, adaptable, serviceable. Bulletin presents typical applications. For complete details, see Bulletin 1001.
428D Louis Allis Co.

* From advertisement, this issue

Any bulletin or catalog . . . yours for the asking

You can get any publication in this literature listing by circling its key number on the Reader Service Post Card (inside back cover). Replies will reach you direct from the manufacturers.

XUM

Motors, Vertical Pump.....Louis Allis vertical pump motors used with vertical turbine pumps will conserve floor space and provide a more compact streamlined installation. See Bulletin 1250.
429A Louis Allis Co.

Packings, Teflon.....Lattice-Braid packings of teflon reduce maintenance, lower replacement costs, reduce wear on pistons and shafts, and increase productive capacity. Full details in Catalog AD131.
370 *Garlock Packing Co.

Packings, Teflon.....Chemiseal packings are made of duPont Teflon—impervious to practically all chemicals—they won't deteriorate, they won't contaminate, they won't "freeze" shaft action. Catalog AD-155.
351b *U. S. Gasket Co.

Reducers, Speed.....Complete information on the Falk lines of concentric shaft and right-angle speed reducers is found in new Bulletin 1105. Revised horsepower selection tables give information at glance.
429B Falk Corp.

Reducers, Speed.....New illustrated 8-page brochure shows the complete line of Strong-Scott speed reducers. Available from stock, units are reported ideal for speed reduction on ½ to 50-hp.
429C Strong-Scott Mfg. Co.

Rings, Pall.....In absorption, distillation or extraction the new Pall Ring offers advantages of major importance. Available in carbon steel, stainless steel, aluminum and copper. Bulletin TP-54.
138 *U. S. Stoneware Co.

Seals, Lubricated.....Chempro Seals give highly economical service on pumps handling acids, alkalis, solvents and other chemical liquids and slurries under diverse operating conditions. See Bulletin 551.
357 *Chemical & Power Products

Seals, Mechanical.....Designers, manufacturers and operators of processing equipment can select the right mechanical seal for a specific condition by referring to new Dura Seal Catalog 480.
429D Durametallic Corp.

Seals, Mechanical.....Combining chemically impervious teflon with a balanced bellows design—Chemiseal mechanical seals last longer and give unsurpassed performance. Full details in Bulletin MS-1155.
351a *U. S. Gasket Co.

Turbines, Solid-Wheel.....Feature reliable, trouble-free operation. Rugged construction and superior design result in savings by keeping maintenance costs down to a minimum. Details in Bulletin No. S-116.
83 *Terry Steam Turbine Co.

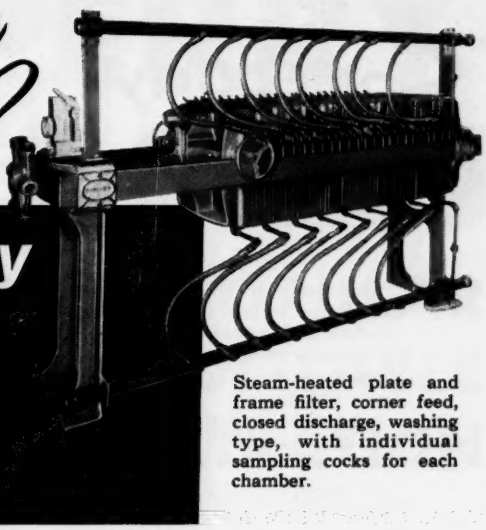
Handling & Packaging

Belts, Conveyor.....Latest information in Catalog 25CB includes new style designations of conveyor belts for general heavy duty service, gives tension ratings for splices, minimum pulley diameters.
429E Raybestos-Manhattan.

* From advertisement, this issue

Can't be Done?

Let's try it in a Filter Press



Steam-heated plate and frame filter, corner feed, closed discharge, washing type, with individual sampling cocks for each chamber.

Tried it in your laboratory filter and it didn't work out? Couldn't get satisfactory flow rate or proper cake build-up? Process too slow? The material too viscous or gelatinous or what-have-you?

We've heard all these before. Yet we have proved a thousand times that what the user first considered a tough filtration assignment turned out a routine problem, readily solved in our laboratory. Of course, many problems were challenging, but Shriver experience and designs overcame them, too.

Shriver's long record in solving problems of filtration, washing, extraction or thickening, with the kind of filter press best suited to specific operating conditions, is your assurance of dependable service from laboratory to plant size equipment.

It will pay you to get the Shriver story. Use the coupon.

SHRIVER
for better filtration

T. SHRIVER & COMPANY, Inc.
802 Hamilton St., Harrison, N. J.
Send me this filtration fact and data book.

Name_____Title_____
Company_____
Street_____
City_____State_____

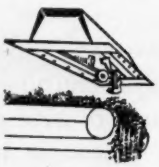
Somebody GOOFED

"Somebody" in this man's plant neglected to guard against tramp iron damage to men, materials and machinery. Maybe he thought a spark-induced explosion was a 100 to 1 chance . . . and the whole plant went up in smoke! Maybe he thought a little iron in the material was unimportant . . . and a contaminated product ruined his company's reputation for product purity! Maybe he thought tramp iron wouldn't damage machinery . . . and repairs and down time ate up a big chunk of profit!

Obviously, that "Somebody" goofed. *He didn't remember that Dings offers a complete line of magnetic separators and metal detectors to safeguard personnel, plants and products from tramp iron damage.*

SOMEBODY COULD HAVE PREVENTED TRAMP IRON TROUBLE WITH THESE

DINGS MAGNETIC PROTECTION PRODUCTS

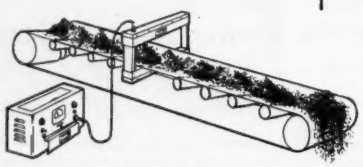


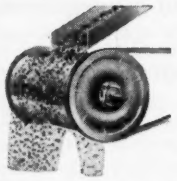
PERMA-PLATE MAGNETS — the most versatile, simplest, and least expensive magnetic separators available for easy installation in chutes, ducts, slides, and over conveyor belts.

SELF-CLEANING RECTANGULAR MAGNETS — equipped with an endless-belt that sweeps iron from the magnet face. Ideal for pulling large quantities of iron from deep burdens on high-speed belts.

METAL DETECTORS — automatically signal the presence of metal in solid, bulk or packaged materials. Available in magnetic or electronic models.

PERMA-DRUMS—assure fully automatic, low-cost iron removal where other type separators may be impractical . . . below apron feeders, chutes, spouts, or in processing machines.





WHICH "SOMEBODY" ARE YOU?

With the Dings complete line to choose from . . . Dings engineering service to help you make the most efficient and economical selection . . . Dings 55 years of experience in solving tramp iron problems like yours — *you* can be the "Somebody" in your plant who increases production and reduces costs! Write us for the solution to your tramp iron problems today.

DINGS MAGNETIC SEPARATOR CO.

Dings

4730 W. Electric Ave.

Milwaukee 46, Wis.

ML-357-2/3

Cable, Interlocked-armor.....New Bulletin DM 5606 contains full information about Anaconda Duralox Cable. Metal tape armor affords high protection against damage—no conduit needed.
121 *Anaconda Wire & Cable Co.

Closures, Protective.....Newly revised illustrated file folder on the recently expanded line of CaPlugs polyethylene closures summarizes data on this line of caps and plugs that safeguard products in transit.
430A Protective Closures Co.

Container, Shipping.....New type Deltainer shipping and storage container is described and illustrated in detail in new bulletin now available. Can be as used part of unit railroad car.
430B Delta Tank Mfg. Co.

Conveyor, Screw.....Standard, stainless-steel screw conveyors available from stock are described in new leaflet which also lists the sizes which are carried in stock for immediate delivery.
430C M-H Standard Corp.

Conveyor Systems.....Entirely new Catalog 157 covers in complete detail the design, features and applications of the infloor Towveyor and overhead Tow-Conveyor. Mechanical details and installation advice.
430D Jervis B. Webb Co.

Conveyors.....Ajax Lo-Veyors are compact, self-contained units that can be suspended from ceilings, along walls, under or at floor levels, giving maximum flow capacity in limited space. Bul. 39.
B462 *Ajac Flexible Coupling Co.

Conveyors, Package.....Folder Form IND-1 shows use of gravity and power belt conveyors in various industrial operations. Describes basic packaged conveyor units, portable lines and controlled flow systems.
430E Rapids-Standard Co.

Conveyors, Pneumatic.....Why you should install a Hoffco-veyor system to convey dry, free-flowing solids pneumatically is detailed in new brochure PN-500 which covers basic types and applications.
430F U. S. Hoffman Machinery.

Conveyors, Screw — Components..... New related ball bearing equipment (trough ends, hangers, etc.) that has been added to company's screw conveyor component line is described in new 6 p. Folder 2489.
44-5 Link-Belt Co.

DragScrappers.....Ask for Catalog A, DragScrapers—24 pages of job photos and specifications. Request Field Reports showing your material being handled by low cost Sauerman Method.
428 *Sauerman Bros.

Materials-Handling Equipment..... Entire line of Lifetime materials handling equipment is illustrated and described in a new foldout leaflet. Included are loading ramps, stackers and pallets.
430G Elizabeth Iron Works.

Scales.....Howe Scale Catalog No. 11 is a handy reference featuring the popular scales from the complete line of standard Howe scales. Includes specifications and spot illustrations.
430H Howe Scale Co.

* From advertisement, this issue

Scales, Railroad Track.....You get all modern "plus" features in Howe four-section straight lever railroad track scale—lever system, main bearings, checking, live and dead rails, etc. Form 685.
431A Howe Scale Co.

Tank, Storage.....Complete description of Chemstor line of glassed steel tanks for low-cost storage is offered in Bulletin 918. These unjacketed, horizontal tanks range from 750 to 35,000 gal. size.
431B Pfaudler Co.

Tanks, Aluminum, Welded.....For storage, pressure vessels and processing equipment built to ASME Code specifications to meet all insurance requirements. Company makes available "Tank Talks."
B467 *R. D. Cole Mfg. Co.

Tractor-Shovels.....HA "Payloader" and larger model HAH do the work of four previous units. Ideal for any bulk materials you have to scoop-up, load or spread. Details available upon request.
377 *Frank G. Hough Co.

Trailer, Transport.....A new trailer that transports sugar and other pulverized and granular bulk solids is described in Bulletin A-19. Text and dwgs. show how to load Airveyor trailer from bins or railroad.
431C Fuller Co.

Truck, Fork.....New 6-page brochure on the new 4,000-lb. capacity Clark-lift-40 fork truck covers maintenance and operating features, specifications and dimensions. Dwgs. show innovations.
431D Clark Equipment Co.

Heating & Cooling

Air Conditioning, Controlled Humidity.....Method removes moisture from air by contact with a liquid in a small spray chamber. Heating or cooling done as separate function. Details in Bulletins 112 and 121.
340 *Niagara Blower Co.

Boiler-Burner Units.....3-Pass design achieves 80% plus efficiencies—delivers maximum operating economy. Adapted for standard burners employing gas, oil or combinations. Request descriptive bulletins.
79 *Titusville Iron Works Co.

Coils, Heating & Cooling.....Stainless—Continuous plate type with smooth drawn ferrules pressure-expanded to produce positive mechanical and thermal bond between tube and fin. Details on request.
119a *Marlo Coil Co.

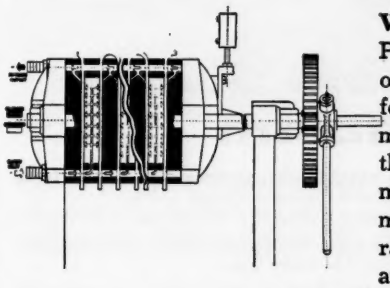
Condensers, Evaporative.....Stainless—3-150 tons. Suitable for indoor or outdoor location. All prime surface condensing coil. Available to your specifications. Company makes details available upon request.
119b *Marlo Coil Co.

Coolers, Ammonia, All Aluminum..... Heat exchanger is all aluminum except the steel Van Stone flanges on the heads and connections. Designed, engineered and fabricated to meet exacting needs. Bulletin 810.
T457 *Manning & Lewis Engrg.

* From advertisement, this issue

WHY THE SPERRY FILTER PRESS IS THE MOST POPULAR AND MOST PROFITABLE METHOD OF FILTRATION

Superior Performance—The Sperry Filter Press can thoroughly wash the cake while it's still in the filter press chamber . . . deliver the filtrate to a higher level than the filter . . . filter emulsions . . . deliver the driest cake . . . and produce an outstanding product of uniform purity and stability.



Versatility—Sperry Filter Presses are made in a variety of models and capacities . . . for use with any type of filter media or filter aid . . . to handle the widest range of filterable mixtures, including viscous materials . . . under a wide range of operating pressures and controlled temperatures.

Economy—Sperry Filter Presses are low in first cost . . . low in upkeep . . . low in installation costs . . . low in operating costs . . . low in depreciation . . . and long in life.

Sperry engineers are always available to put all the advantages of the Sperry Filter Press to work for you. Write today for an analysis of your particular filtration problems, or ask for your free copy of the SPERRY FILTRATION CATALOG, containing specifications and other technical data for your reference.

D. R. SPERRY & CO., BATAVIA, ILLINOIS

Filter Plate Presses • Closing Devices • Filter Bases

Sales Representatives

George S. Tarbox 808 Nepperhan Ave. Yonkers, N. Y.

B. M. Pilhashy 833 Merchants Ex. Bldg., San Francisco, Cal.

Alldredge & McCabe 847 E. 17th Ave. Denver, Colorado

Texas Chemical Eng. Co. 4101 San Jacinto, Houston, Texas

D. R. SPERRY & COMPANY
Batavia, Illinois

☐ Send Free Sperry Catalog
☐ Have your Representative Contact us

Name_____

Company_____

Address_____

City_____ State_____

This Ampco Pipe has a ¾" wall, to handle sulphuric acid sludge in oil-company operation.

Sulphuric Acid Sludge No Problem

for major oil company,* in 1000-lb. transfer service

Its Ampco Pipe and Fittings resist corrosion

Ampco Pipe successfully handles problem liquids like these:

Boiling sulphuric acid (up to 50%)

Hot concentrated caustic solutions

Phosphoric and acetic acids

Phthalic anhydride

Phenols

Furfural

Brine

*Name upon request

Many other companies avoid corrosion shutdowns this same way.

Ampco Pipe is made from an exclusive aluminum-bronze alloy that . . .

(a) Resists many acids and caustics.

(b) Withstands the action of abrasive solids in suspension—resists cavitation-pitting.

(c) Has a Brinell hardness of 150 and tensiles up to 70,000 psi.

(d) Stands up under wrenches and hammers, without thread distortion and subsequent leakage.

(e) Has high velocity tolerance — flow rates of 18-20 fps.

You can get Ampco Pipe in all standard sizes, many from stock. Fittings are available to 3000 psi; flanges, to 5000 psi.

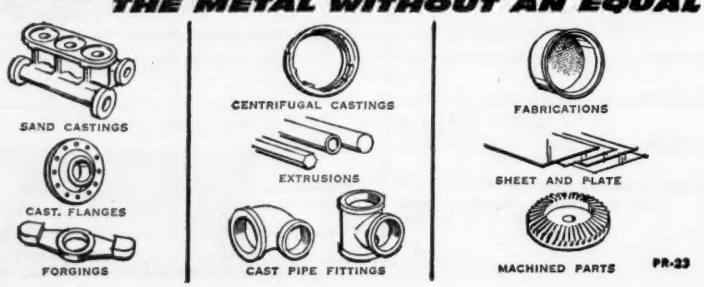
Write us concerning *your* problem.

AMPCO METAL, INC.

Dept. CE-5, Milwaukee 46, Wis. • West Coast Plant: Burbank, Calif.

AMPCO®

THE METAL WITHOUT AN EQUAL



PR-23

LITERATURE . . .

Fans, Cooling Tower.....Revised catalog, Bulletin A-111B, describes line of adjustable-pitch cooling tower and heat exchanger fans and includes specifications and performance data.
432A Hartzell Propeller Fan Co.

Fans, Industrial.....Photographs of many different types of heavy duty industrial fans both ready for service and installed are included in Bulletin 502. Index of manufacturer's models also included.
432B Robinson Ventilating Co.

Generators, Steam.....Vogt steam generators are available in bent tube types and straight tube forged sectional header types for solid, liquid or gaseous fuels. Product bulletins available upon request.
277 *Henry Vogt Mach. Co.

Heat Exchangers.....How a Paracoil obstacle course gives you better heat exchange. Davis will create the proper turbulence to give you most efficient heat transfer in equipment. Request Bulletin 1000.
423 *Davis Engrg. Corp.

Heat Exchangers.....K-Fin coolers covered in Bulletin 1200 are designed and constructed to cool hydrogen and air circulating from generator windings, also process air and gases.
432C Griscom-Russell Co.

Heat Transfer Systems.....Capacities can range from small portable units to large gas- or oil-fired units generating from 250,000 to over 10,000,000 B.T.U.'s per hour. Names of designers & manufacturers.
135b *Monsanto Chem. Co.

Heaters, Air.....Specify "Surface" air heaters and get these returns: save fuel, save installation costs, single burner unit. Build these savings into your convection heating equipment. Literature H54-15.
L464 *Surface Combustion Corp.

Heaters, Electric.....In the new 1957 catalog of G. E. heaters and heating devices you'll find a 16-page power requirements section showing short and long calculations of heating applications.
432D General Electric Co.

Heaters, Electric Oil.....Data Sheet 709B tells how electric oil heaters raise heavy fuel oils to the temperatures required for good combustion and performance in modern oil-burning systems.
432E Hauck Mfg. Co.

Heaters, Far-Infrared.....Illustrated bulletin describes advantages of Chromalox electric radiant heaters, their design, and variety of applications. Includes specifications, controls & prices. Bulletin CS604.
362b Edwin L. Wiegand Co.

Heaters, Far-Infrared.....Bulletin describes Chromalox Adjustable Area Far-Infrared Heaters. Includes description of features, accessories, information on how to install type Rutu Elements, etc. Bulletin CS-607.
362c Edwin L. Wiegand Co.

Heaters, Immersion.....Complete line of four basic types for all needs described in 4-page bulletin includes exclusive new "U" type designed to solve difficult heating of plating and pickling baths.
432F Glo-Quartz Electric Heater

* From advertisement, this issue

Heaters, Thermal Liquid.....Company's thermal liquid heaters offer these advantages: accurate temperature control; high heat transfer rates; low cost, low pressure operation; heat on demand. See Bulletin TLH.
324 *International Boiler Works.

Heating Systems, Dowtherm.....Descriptive information on Dowtherm heating systems for processes requiring precision control of high constant temperatures at low pressures, in Bulletin ID-54-5.
89 *Foster Wheeler Corp.

Replacers, Lamp.....Now any infrared reflector bank can be equipped with glassless, glareless, self-cleaning Metaray elements. Radiation spread more uniformly. Complete details in Bulletin L-1104.
362d *Edwin L. Wiegand Co.

Radiant Panels, Modular.....Modular panels completely factory assembled with built-in continuous bus, reflector, insulation, frame and mounting. High-intensity heat source in four standard sizes. Bul. CS-606.
362e *Edwin L. Wiegand Co.

Thermometer Elements, Resistance.... Answer industry's need for a better way to measure surface temperatures, Flexible, easy to apply, low cost, fast response. Full details in Brochure No. T-56.
T465 *Arthur C. Ruge Assoc.

Thermo-Panels.....Cost less and perform better—an improvement on pipe coils. Save space and heat or cool more efficiently. For use in heating and cooling of liquids, slurries, etc. Bulletins 355 and 257.
TR464 *Dean Thermo-Panel Div.

Towers, Cooling.....Stainless—2-150 tons. Suitable for indoor or outdoor location. Marlo heat transfer equipment now available to your specifications. Company makes information available on request.
119c *Marlo Coil Co.

Towers, Cooling.....Two brochures should prove helpful: "Comparative Performance of Cooling Tower Packing Arrangements" and "Answers to 15 Questions about Pritchard Induced Draft Cooling Towers."
134 *J. F. Pritchard & Co.

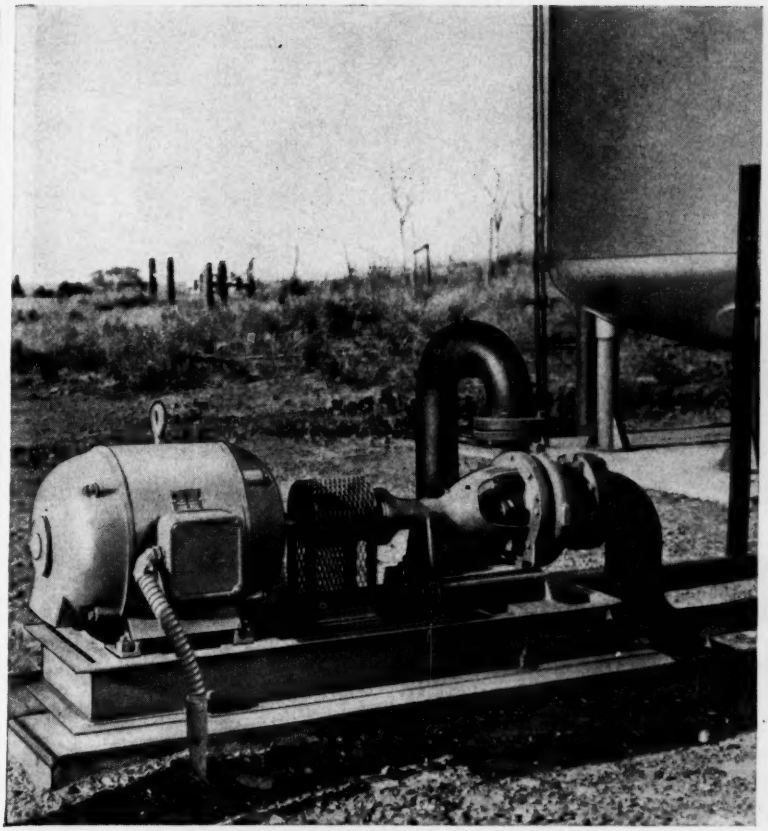
Traps, Steam.....Major reductions in steam trap installation and maintenance work and cost can be achieved by standardization on one make of trap—permits standardized hookups. Steam Trap Book.
222 *Armstrong Machine Works.

Traps, Steam . . . . . Literature now available details advantages of a new, low-cost Series A thermostatic trap designed for frequent shutdown and startup, handling of large air volumes.
433A Clark Mfg. Co.

* From advertisement, this issue

Any bulletin or catalog . . . yours for the asking

You can get any publication in this literature listing by circling its key number on the Reader Service Post Card (inside back cover). Replies will reach you direct from the manufacturers.



A Centrifugal Pump Salt Water Can't Damage!

Ampco Pumps are ideal for salt-water disposal and flooding operations:

- *Transfer service*
- *Pumping over aerators*
- *Pumping through filters*
- *Back-flushing filters*
- *Delivery of treated water*

It's an AMPCO . . . made from aluminum bronze that contains no zinc.

Ampco Pumps resist corrosion, erosion, abrasion, cavitation-pitting, and dezincification. They are made from Ampco alloys engineered specifically to resist salt water corrosion.

Durability isn't the only advantage of Ampco Pumps. They have high efficiency . . . up to 85%. You pay considerably less for power.

Ampco Pumps are available in more than 100 different combinations, with speeds from 1750 to 3500 rpm; capacities to 600 gpm; heads to 300 feet.

Contact us in Milwaukee for the name of your nearest AMPCO PUMP DISTRIBUTOR.

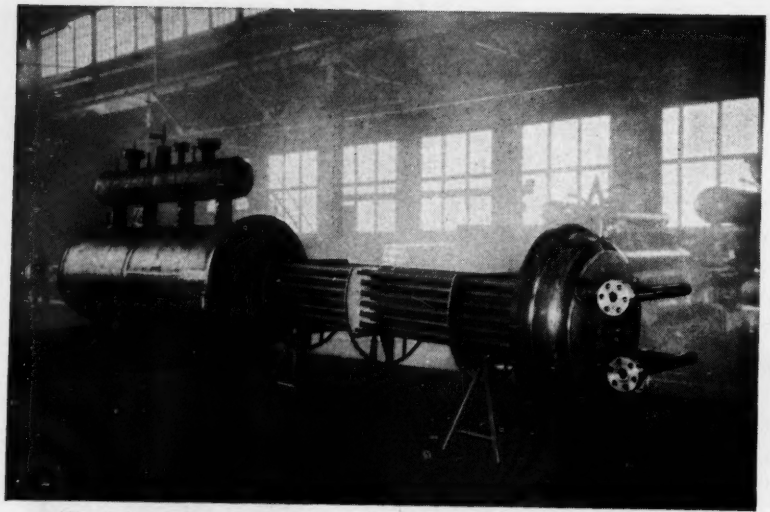
AMPCO®

AMPCO METAL, INC.

Dept. CE-5, Milwaukee 46, Wis. • West Coast Plant: Burbank, Calif.

THE METAL WITHOUT AN EQUAL

P-23



Vilter high pressure synthesis condenser fabricated for a prominent chemical company.

Q- How did Vilter cut costs on a High Pressure Synthesis Condenser?

A- Through practical redesign of the condenser tube lay-out.

A real challenge was tossed at Vilter a short time ago. How to produce a high pressure synthesis condenser to meet design specifications . . . yet meet the customer's budget requirements.

Originally the customer specified a 72" shell with a return bend type tube bundle of 2" O.D. heavy wall steel tubing. The cost of this design exceeded the budget. After careful study, Vilter engineers solved the problem by changing to smaller centers on the return bends and the use of standard Vilter tube supports. These changes materially reduced the shell diameter *without* a reduction in vessel capacity. The net result was a price reduction of 15%. This is another example of successful Vilter engineering to meet customer needs.

Vilter makes all four basic types of heat exchangers: shell and coil, shell and tube, shell and tube bundle, and atmospheric . . . and in every possible modification. Vilter can give you the most efficient heat exchange equipment and pressure vessels with working pressures as high as 10,000 psi for specific purposes. Consult with Vilter.

Vilter®

QUALITY CRAFTSMANSHIP that lasts...

ENGINEERING DESIGN that guarantees performance

REFRIGERATION and AIR CONDITIONING

THE VILTER MANUFACTURING COMPANY, Milwaukee 7, Wisconsin

Air Units • Ammonia & Freon Compressors • Booster Compressors • Baudelot Coolers • Water & Brine Coolers • Blast Freezers • Evaporative & Shell & Tube Condensers • Pipe Coils • Valves & Fittings • Pakice & Polarflake Ice Machines

LITERATURE . . .

Traps, Steam.....Give faster, more effective condensate removal. Powerful valves action, positive shut-off, high capacity & each unit service tested. For more details, request new Bulletin No. 10-55.
214 *W. H. Nicholson & Co.

Traps, Steam.....New Sarco type TD steam trap is machined from a solid block of stainless steel. Has only 3 parts . . . cap, disc and body . . . and not even a valve-closing mechanism. Details in Bulletin 257.
289 *Sarco Co.

Vaporizers, Dowtherm.....Completely packaged, gas-fired Eclipse Dowtherm Vaporizers give fast, uniform process heating, and their low operating pressures makes them safer. Details available in Catalog A-100.
344 *Eclipse Fuel Engrg. Co.

Washers, Air.....Stainless steel air washers custom built to your specifications for: washing, cleaning, humidifying, dehumidifying, heating, and cooling. Company makes details available on request.
119d *Marlo Coil Co.

Instruments & Controls

Accessories, Instrument . . . . . Accessories for gages, dial thermometers and recorders described in bulletin 600 include attachments to protect internals against corrosives and pressure, tools, fittings.
434A United States Gauge.

Analyzers, Carbon Monoxide.....Continuous carbon monoxide analyzers described in 4-page folder detect accumulation of dangerous concentrations of gas in chemical plants, metallurgical plants, etc.
434B Mine Safety Appliances Co.

Analyzers, Vibration.....Where you can use new models 300 and 400 to measure, troubleshoot and balance out vibration is pointed out in a new leaflet that also details component features and specifications.
434C Int'l Research & Devel.

Annunciator System.....New 20-page bulletin "Scam Self-Policing Annunciator Systems for Industry" tells how these systems continuously supervise control systems and machinery and conserve manpower.
434D Scam Instrument Corp.

Automation Systems.....New company publication "Alden Systems Illustrated News" carries timely information and application stories on automation, cost-cutting methods and work simplification.
434E Alden Systems Co.

Balance, Gas Density.....For continuous, accurate measurement of process gas streams. Features: wide ranges, rapid response, sensitivity and accuracy, corrosion resistant, etc. See Data File 22X-57.
446 *Arnold O. Beckman Inc.

Calibrator, Pressure.....How a new primary pressure standard, type 6-201, operates as an air deadweight tester to calibrate any pressure-measuring device is detailed in new Bulletin 1581.
434F Consolidated Electrodynamics.

* From advertisement, this issue

Comparators.....Fully illustrated, 100 p. tells how to use pH and chlorine control for water supplies, process solutions, production processes in 34 basic industries. Covers complete line of comparators.
L452 *W. A. Taylor & Co.

Control, Edge Position.....Handles any web of rubber at any speed; powerful; dependable; easy to maintain; non-clogging; non-contact position sensing of the rubber edge. Bulletin No. 30.1.
435A Askania Regulator Co.

Control, Oxidation-Reduction ..... Oxidation-reduction processes can be controlled accurately and conveniently with the new O-R-P cell described in a bulletin now available from the manufacturer.
435B Fischer & Porter Co.

Control Systems.....Taylor Trans-Scan-Log Control System is an evolutionary step interlocking scanning and logging with process control to put complete information in front of the operator. Bulletin 98268.
54-5 *Taylor Instrument Cos.

Control Systems, Temperature..... Several forms of complete control systems available as stock items or custom built are detailed in Bulletin CS. Systems come fully wired and equipped.
435C West Instrument Corp.

Control, Temperature Limit.....Precision control of critical temperatures in high-cost processing operations is the function of model HL 15-10 high-temperature limit control described in Bulletin 311.
435D Partlow Corp.

Controller, Indicating Pneumatic..... Compact, moderately-priced indicating pneumatic control instruments described in Catalog C(600/700)1 cover temperatures from 0 to 1,000 F.
435E Minneapolis-Honeywell.

Controller, Temperature.....Leaflet reports that precision temperature controller for laboratory and pilot plant controls within ±0.001 C. with ranges from −100 C to +500 C. with great reliability.
435F Bayley Instrument Co.

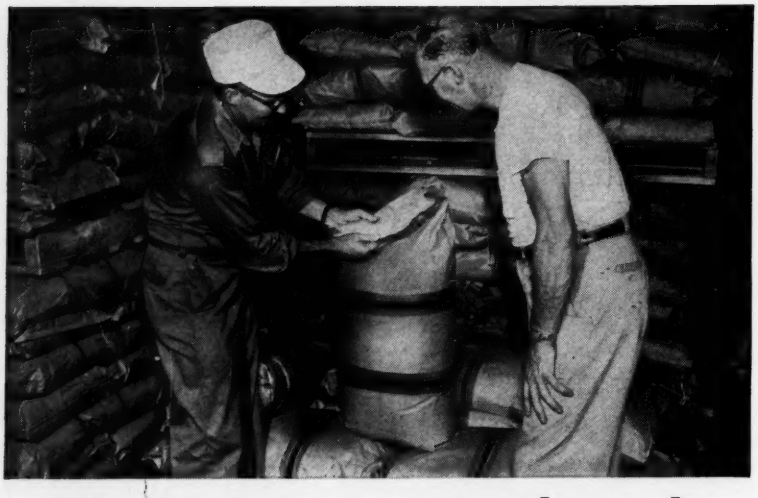
Controls.....Advanced electrical design of Allis-Chalmers Size 4, 5 and 6 control incorporates a modern principle of arc interruption for low voltage, high horsepower applications. Bulletin 14B8615.
99 *Allis-Chalmers Mfg. Co.

Controls, Modulating.....New Fultrol Thermostatic Pilot Controller—a simple compact unit that now enables you to control temperatures up to 600°F. with proportional accuracy, but at on-off cost. Cat. 10-28JC.
361 *Fulton Sylphon Div.

Controls, Pressure-Vacuum.....Four bulletin pages cover pressure-vacuum controls—Types G9, H9, J10 in Bulletin 5-1; Type H12 in Bulletin 5-2; Type J6 in Bulletin 5-3 and Type J96 in Bulletin 5-4.
436A United Elec. Controls Co.

* From advertisement, this issue

WHOOSH!
NO MORE FIRE
Point horn, pull trigger, fire's out! That's all it takes to knock out deadly fire with instant-action Kidde dry chemical portable extinguishers! So easy to use, even inexperienced operators get perfect fire-fighting results. Kidde's patented diffuser horn spreads dry chemical powder over wider area for greater fire-killing power. Trigger-release means faster action, feels more natural in the hand. Pick the Kidde dry chemical portable to fit your needs: 5, 10 lb. pressurized (recharged at any commercial air pump), 20, 30 lb. cartridge operated. For more information on dry chemical, carbon dioxide and wet chemical extinguishers, write today for Kidde's F-8 catalog and name of nearest distributor.
Kidde
Walter Kidde & Company, Inc.
528 Main St., Belleville 9, N. J.
Walter Kidde & Company of Canada Ltd.
Montreal — Toronto



Now, a stronger thread for bags—at low cost!

BAGS SEWN WITH "SUPER CORDURA" withstand rugged handling, reducing spillage sharply.

"SUPER CORDURA" permits use of smaller needles, preventing material loss due to sifting.

SAVE TWO WAYS WITH NEW DU PONT "SUPER CORDURA"

REG. U. S. PAT. OFF.

High Tenacity Rayon

- **Bags sewn with it cost less**
- **Cuts cost of closing operation**

Du Pont "Super Cordura"* gives you greater seam strength—yet bags sewn with it cost you less. Drop tests prove this strength minimizes the danger of seam breakage.

"Super Cordura" saves you money in your own closing operations, too. It lets you use one size thread for most jobs, meaning reduced thread inventory. And it's treated with a special finish to insure good sewability.

Consider the advantages of bags sewn with Du Pont "Super Cordura" the next time you order multiwalls . . . and order it for use in closing, too.

E. I. du Pont de Nemours & Co. (Inc.), Textile Fibers Department, Wilmington 98, Delaware.

*"Super Cordura" is Du Pont's registered trademark for its high tenacity rayon yarns.

DU PONT

REG. U. S. PAT. OFF.

Better Things for Better Living . . . through Chemistry

THREAD OF "SUPER CORDURA"... easier to sew ... costs less than conventional thread . . . extra-strong

LITERATURE . . .

Controls, Temperature.....Features: cuts initial control costs; costly production stoppages; control maintenance costs. Controls for gas, liquids and solids in –30°F. to 1200°F. ranges. Condensed Catalog CC.
438 *Partlow Corp.

Controls, Temperature.....17 p. catalog presents company's line of remote bulb temperature controls . . . industrial, aircraft, marine, special purpose. Includes features, specifications, etc. Catalog Sec. 200.
346 ***United Elec. Controls Co.**

Detector, Fire.....In a new 4-page brochure, you'll find how the rate-compensation principle allows Detect-A-Fire units to actuate at selected protection level regardless of temperature change rate.
436B Fenwal, Inc.

Detector, Vibration.....Bulletin Entitled "Optron Displacement Follower" discusses an optical device that measures displacement and vibration regardless of size, shape or composition of material.
436C Optron Corp.

Dryer, Instrument Air.....Full details, including installation and operating instructions, are given in 4-page Catalog 3150 on the King instrument air dryer. Unit removes moisture from compressed gases.
436D King Engineering Corp.

Electrodes, pH.....Complete information about L&N industrial process pH electrodes and their housings can be obtained from new 4-page Data Sheet N-S5(2). Engineering features, ordering instructions.
436E Leeds & Northrup Co.

High Pressure Equipment.....Superpressure Division—designers and manufacturers of instruments developing pressures from atmospheric to 100,000 psi. Catalog 406-C describes superpressure instruments.
10 *American Instrument Co.

Indicator, Temperature.....Pyrotac constantly indicates temperature of heated equipment and sounds an alarm and/or shuts down the equipment at a safe, preset temperature. Full details in Pyrotac Bulletin.
R450 *Illinois Testing Labs.

Indicator, Temperature.....Information about the Speedomax G potentiometer instruments is presented in Data Sheet ND46-33(23). Temperatures are indicated at flick of switch on drum scale.
436F Leeds & Northrup Co.

Instrumentation, Electronic.....The Batchetron is . . . Fairbanks-Morse electronics instrumentation plus-accurate weighing in the Fairbanks-Morse tradition. New bulletin gives applications. Bul. ED-14.
386 ***Fairbanks-Morse & Co.**

Instrumentation, Rotary Kiln.....If you are planning new kilns or plant modernization programs, consider Leeds & Northrup specialized experience in rotary kiln instrumentation. Details in Folder N-0720(1).
66 *Leeds & Northrup Co.

* From advertisement, this issue

Instruments.....Advantages of a new line of plastic-housed instruments are detailed in a new bulletin now available. Low-cost, small instruments indicate, transmit and control pressure and temperature.
437A Fischer & Porter Co.

Instruments, Panel.....Consotrol instruments require the minimum of panel space, yet provide unsurpassed operator convenience, visual accuracy, and ease of maintenance. Full details in Bulletin 13-18.
46-7 *Foxboro Co.

Instruments, Radioactivity . . . . . Over thirty new instruments for measuring radioactivity have been added to a new edition of Nuclear-Chicago's catalog. A wide range of equipment is covered.
437B Nuclear-Chicago Corp.

Measurement, Viscosity.....The Viscometran is an industrial instrument which provides accurate and continuous viscosity measurements of materials under actual process. Request product bulletin.
437C Brookfield Engrg. Labs.

Precipitator Control.....New bulletin on the Cottrell automation system tells how system controls power input to electrostatic precipitator to eliminate manual adjustments and increase efficiency.
437D Research-Cottrell.

Psychrometer.....New 4-page bulletin tells how the new Bendix Friez psychrometer provides extremely accurate wet and dry bulb temperatures for determining relative humidity and dew point.
437E Gardner Laboratory.

Recorders, Multipoint.....Bulletin F-7955 highlights the easy-to-read, easy-to-operate, easy-to-service features of Series 8000 Wheelco electronic multipoint recorders for up to 16 points on one chart.
437F Barber-Colman Co.

Recorders, Potentiometer.....Bulletin covers new 8000 series potentiometer recorders—indicating and recording data, chart drive and calibration, power supply and amplifier, etc. Bul. F-7747.
437G Barber-Colman Co.

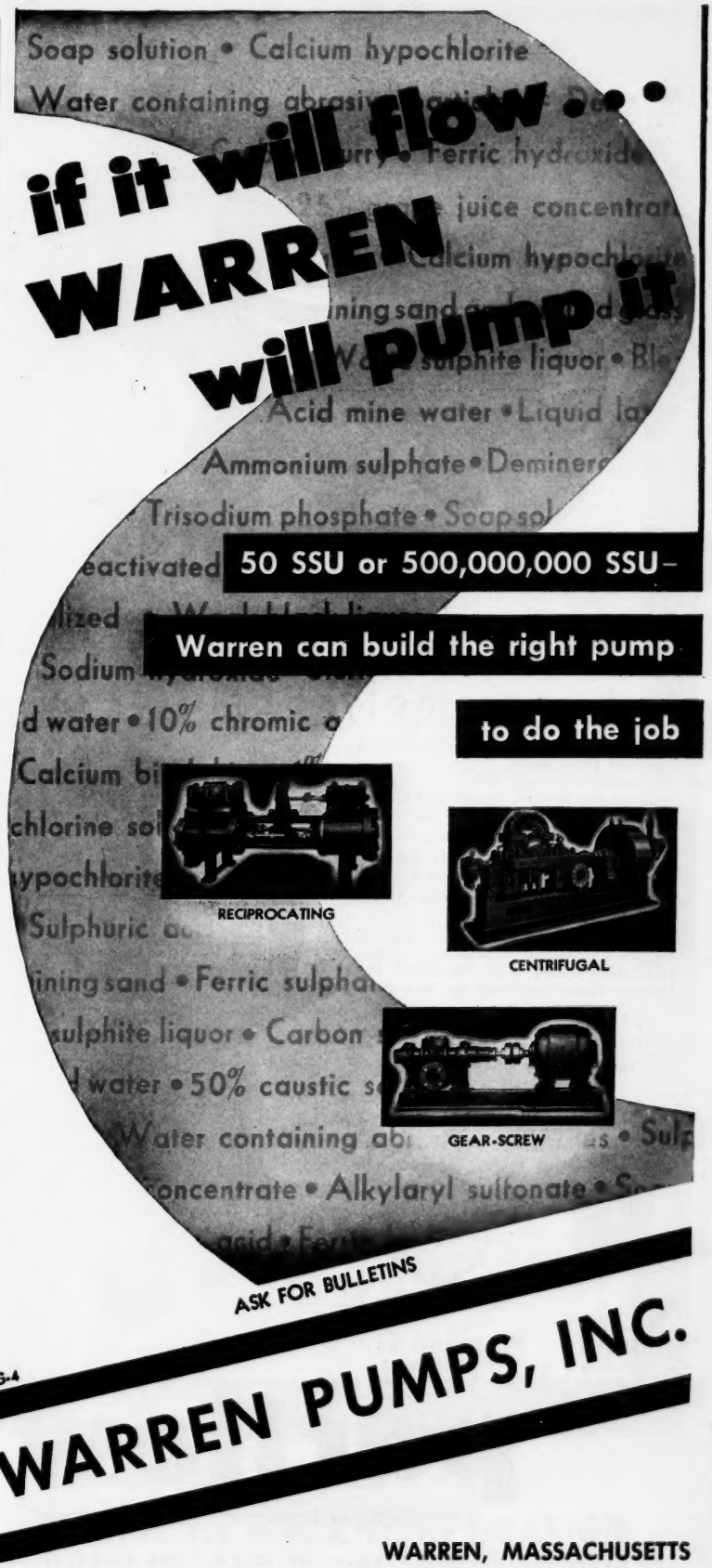
Regulators, Gas.....Now that maximum inlet pressure of Rockwell's "120" sensitive regulators has been doubled, you can find revised size, capacity and weight tables in Bulletin 1044, Rev. 6.
437H Rockwell Mfg. Co.

Regulators, Valve.....Revised 12-page bulletin 1082, Rev. 2, covers Rockwell's "014" low-pressure balanced valve regulators. Schematic shows use of high-pressure "173" regulator to pilot-load the "014".
437I Rockwell Mfg. Co.

Regulators, Voltage.....Stabiline automatic voltage regulator will make sure that your electrical equipment operates at its most efficient and economical rating. Full details in Bulletin S657.
197 *Superior Electric Co.

Rotameter.....Single-page leaflet gives details of the SM-11 Purge meter designed to withstand unusual amounts of abuse. Rated for 1,000 psi., meter is as unbreakable as pipe in line.
437J Lester-McKinney, Inc.

* From advertisement, this issue



RUGGED...

but extremely SENSITIVE!

PARTLOW TEMPERATURE CONTROLS are built to withstand rough usage, but they're also extremely sensitive to slightest temperature changes. They'll take a lot of punishment without upsetting their accuracy and precision.

If your process requires precise temperature control in the –30°F to 1200°F range, you can do it better . . . *and at lower cost* . . . with Partlow Controls.

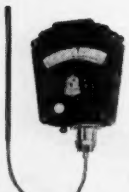
They're less complicated than thermocouples. Thick-walled capillaries and seamless tubing assure almost indefinite life. Elements can be replaced on the spot.

What's your control problem?

Tell it to Partlow!

THE PARTLOW CORP., Dept. E-557
New Hartford, N. Y.
Offices in All Principal Cities

SEND FOR THIS **FREE** CONDENSED CATALOG



MODEL LS
Indicating Temperature Control

MODEL RS
Recording Temperature Control

partlow

the pioneer in mercury thermal controls

NO MATTER WHAT YOU MAKE, PARTLOW CONTROLS WILL HELP MAKE IT BETTER

LITERATURE . . .

Switches, Float.....Indication and control of liquid oxygen level are discussed in Bulletin 1066 dealing with float switches. Weighing ¼ lb. switches work from -320 to 200 F. to hold level where desired.
438A Revere Corp. of America.

Thermocouple, Spring-Loaded..... Where pressure contact is needed for efficient temperature measurement, the new Brown spring-loaded thermocouple assures this contact. Specification S001-6.
438B Minneapolis-Honeywell.

Thermometer Probe, Resistance..... By utilizing a grid of extremely fine platinum wire welded to platinum lead wires, this probe is capable of operation over the range of from 0 to 1200° C. Bulletin.
438C Arthur C. Ruge Assoc.

Thermometers.....Thermotrols — 4000 Series Thermometers—have these features: mercury-actuated, electronic control action, invar metallic compensation for case. Request Bulletin F-8042.
438D Barber-Colman Co.

Transmitter, Non-Indicating ..... Brown, non-indicating, pneumatic pressure transmitter for vacuum or pressure measurement is described in Specification S705-1. Ranges 0-90 in. water to 0-4,000 psi.
438E Minneapolis-Honeywell.

Transmitters, Pressure.....Advantages of the "null-balance-vector" principle in pressure and differential pressure transmitters are covered in Folio No. 56-12 and Folio 56-13A which describes these new units.
438F Republic Flow Meters Co.

Viscometer, Continuous.....Catalog VT-57 gives complete information about the Brookfield Viscometran and its applications to continuous in-process measurement and control viscosity.
438G Brookfield Engineering Lab.

Pipe, Fittings, Valves

Clamps, Plastic Pipe..... New catalog page PP-1256-15 shows general specifications and descriptive data on Sure-Tite stainless-steel clamps for plastic pipe. They are designed for all sizes of plastic pipe .
438H Wittek Mfg. Co.

Couplets.....W-S Couplets are designed to function as universal outlet connections for tanks, process vessels and pipe lines. Eliminate need for large, expensive field inventories. See Bulletin CP-1-57.
343 *Watson-Stillman Fittings.

* From advertisement, this issue

Any bulletin or catalog . . . yours for the asking

You can get any publication in this literature listing by circling its key number on the Reader Service Post Card (inside back cover). Replies will reach you direct from the manufacturers.

Coupling.....The HK quick-connect, quick-disconnect coupling described in Bulletin 270 uses Teflon seals throughout. Coupling will handle acids, alkalis, solvents, and steam over wide temperature range.
439A Snap-Tite, Inc.

Couplings.....Falk Steelflex Couplings will prolong machinery life and save money. They are versatile, efficient and economical. Engineering bulletin includes selection and dimension tables.
96 *Falk Corp.

Fitting, Lubrication.....Bulletin BU-61 describes and illustrates advantages of special relief-type lubrication fitting. Attaches to bearing housings of motors, machines or pillow blocks.
439B Keystone Lubricating Co.

Fittings, Stainless Steel.....Speedline fittings simplify pipeline design. Details of the greater design flexibility possible with Speedline fittings . . . at lower cost . . . available in catalog.
360 *Horace T. Potts Co.

Hose, Metal, Flexible.....Engineered and manufactured to absorb the costly beating your piping system is now taking . . . efficiently and economically. Company makes details available in Bulletin IND 4.
336 *Packless Metal Hose.

Joint, Expansion.....New Bulletin EJ-1915 describes the Yarway type W Gun-Pakt expansion joint which features an improved one-piece design of body and gland. Data also for figuring pipeline expansion.
439C Yarnall-Waring Co.

Joints, Expansion.....Free-flexing and controlled-flexing; dual and multiple types; balanced joints and other special designs; all in stanless steel, monel, and other workable alloys. See 28 p. Design Guide.
354 *Flexonics Corp.

Multitube, Polyethylene.....Offers economy with lasting dependability in your instrument tubing problems. Can be pulled through conduit or raceways. Furnished in 7 contrasting colors. Bulletin H-356.
B457 *Crescent Insulated Wire.

Nozzles, Spray.....Company provides a 48 p. industrial catalog with full data on thousands of standard and special nozzles—for every type of spraying. Also information on related equipment. Catalog No. 24.
T459 *Spraying Systems Co.

Nozzles, Spray.....For spraying, washing, rinsing and cooling, Yarway spray nozzles will improve efficiency of your spray equipment. No internal vanes to clog or hinder flow. See Bulletin N-618.
R460 *Yarnall-Waring Co.

Pipe.....Request your free copy of this new pipe fabrication team bulletin, called "How Piping is Fabricated." Tells how Flori fabricates its pipe and how they sell this pipe as a team.
67 *Flori Pipe Co.

Pipe, Channel.....Chemi-Drain channel pipe channels hot sulphuric dilute for processing; safely drains corrosive waste chemicals. Unaffected by acids or other corrosives. Full details in 4 p. bulletin.
B465 *Logan Clay Products Co.

* From advertisement, this issue

The Chemical Industry Looks To AMERICAN AGILE

■ During the many years AMERICAN AGILE has worked in corrosion-resistant plastics, its outstanding reputation was built upon its performance in research, development and quality controlled production of plastics for the chemical process industries.

• In 1949 as one of the nation's first commercial processors of polyethylene, American Agile evolved the techniques of molding and fabricating the plastic.

• In 1950 Agile introduced the spraying and forming of polyethylene structural shapes to meet operating conditions in which other materials failed. Also, Agile introduced coating of metal targets with modified polyethylene.

• In 1951, welding of polyethylene and polyvinyl chloride was introduced in this country by Agile which then made the techniques and the welding equipment available to other processors.

• In 1954 another Agile first was the introduction of irradiated polyethylene molded parts whose range of industrial applications was enlarged through the exposure to atomic radiation.

• AND TODAY — with still another first in foam polyethylene and polyethylene filter cloth for high temperature applications, American Agile is expanding both research and production to meet the demands of cost-conscious, progressive thinking designers, engineers and management for more efficient production equipment for better quality products at lower cost.

What Are Your Needs? Whatever your product may be, you will find American Agile a prime dependable source of supply for your processing equipment requirements.

Write for literature.

AGILENE AGILIDE

Established in 1932

AMERICAN AGILE CORPORATION

■ 5461 Dunham Road • Maple Heights, Ohio ■

Fansteel
Corrosionomics
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A JOURNAL OF USEFUL INFORMATION FOR THE SOLUTION OF CORROSION PROBLEMS

Chemical Resistance of Tantalum to Fluorine, Chlorine, Bromine and Iodine

Fluorine attacks tantalum at room temperature. It is not known, however, what the rate of attack is at low concentrations of fluorine in gas mixtures.

Chlorine begins to attack tantalum at above 200°C, the rate increasing as the temperature becomes higher. Wet or dry, chlorine does not affect tantalum at temperatures ordinarily encountered in chemical processes. Thus, while the metal cannot be used for high temperature chlorinations, such as the production of titanium tetrachloride by the reaction of chlorine on a mixture of TiO_2 and carbon, it is widely used for chlorinations in aqueous and organic solutions at temperatures below 200°C. Tantalum is also inert to the hydrolysis products of chlorine, at all concentrations. It finds use in the form of meter components, thermowells, sparger tubes, heaters and heat exchangers handling free chlorine or chlorine-containing solutions in a great variety of chemical processes ranging from the introduction of chlorine into municipal waters to the heating and cooling of chlorinated brine in electrolytic cell plants producing chlorine and caustic.

Bromine begins to attack tantalum above 300°C. Tantalum is inert to bromine, wet or dry, at temperatures ordinarily encountered in chemical processes. In the bromine industry it is used to handle both chlorine and bromine. (See "Corrosionomics," July, 1956). Units condensing hot (190°-212°F) bromine containing water and chlorine have been in continuous use for 20 years without corrosion of the tantalum. Tantalum is inert to the hydrolysis products of bromine, at all concentrations, and is widely used for brominations in aqueous and organic solutions at temperatures below 300°C.

Iodine attacks tantalum above 1000°C, but the metal is inert at lower temperatures. In high temperature application, tantalum is used as a shield in the deBoer and van Arkle process for the preparation of pure metals, such as titanium and zirconium by the decomposition of metal iodides on a hot filament into the metal and free iodine.

The interhalogen compounds, with the exception of those containing fluorine, likewise do not attack tantalum at normal temperatures.

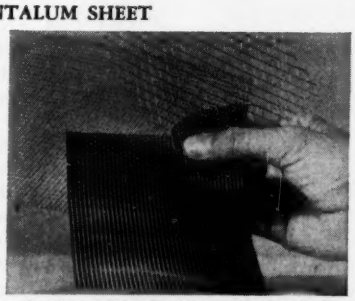
EXPANDED TANTALUM SHEET

It is now possible to fabricate expanded tantalum sheet in thicknesses from 0.003 to 0.075 inch and in widths up to 54 inches.

Sheet widths larger than 54 inches can be produced by welding smaller widths together.

Expanded tantalum sheet should prove useful as screens for chemical equipment exposed to acidic and other media which do not attack tantalum; anode baskets in electroplating baths; support screens for retaining packing in towers; and supports for glass and synthetic fiber cloths used in filters and centrifugers.

Platinum can be deposited as a thin coating upon expanded tantalum and the composite should be useful as catalyst screens and as anodes for electrolytic cells. In these applications tantalum acts as an inert support material and reduces the amount of platinum required.



Tantalum can be produced in a variety of meshes.

Free Tantalum Test Kit

A corrosion test kit, available without charge to research technicians, contains both tantalum sheet and wire. Request it on your letterhead.

The above condensation is typical of articles which appear in CORROSIONOMICS, a Fansteel publication. Mail us your name for inclusion on our mailing list.

For further data on the above, write:

G572A

FANSTEEL METALLURGICAL CORPORATION CHEMICAL EQUIPMENT DIVISION NORTH CHICAGO, ILLINOIS, U.S.A.

LITERATURE . . .

Pipe, Plastic.....Ace Revivor is a new rigid threaded plastic pipe with good aging and high impact strength. Not affected by most inorganic acids and alkalis. Company offers full details in Bulletin CE-56.
322c *American Hard Rubber Co.

Pipe, Plastic.....General-purpose moderately priced rubber-plastic pipe handles most common chemicals to 170°F . . . except few strong acids & organic solvents. Tough, odorless, tasteless. Bulletin 80.
322a *American Hard Rubber Co.

Pipe, Plastic.....Polyvinyl Chloride is the unparalleled material for plastic pipe. It's a high quality unplasticized-rigid pipe designed to do a better job than any other material. Details in Bulletin 24.
223 *U. S. Steel Corp.

Pipe, Rigid.....Koroseal rigid pipe is exceptionally easy to install. Can be threaded with standard pipe threading equipment, quickly joined to Koroseal valves and fittings. Details available in booklet.
19 *B. F. Goodrich Industrial.

Pipe, Saran Lined.....Saran lined pipe,fittings and valves cut corrosion costs . . . can be cut in the field with available pipe fitter's tools. Liquid never touches metal in saran lined pipe. Request details.
129 *Saran Lined Pipe Co.

Pipe Tool.....Through the large, clear illustrations and explanatory text in a new 24-page book you can learn how easily tube or pipe can be notched to make joints for welding with the Wallace Notcher.
440A Wallace Supplies Mfg. Co.

Pipe & Tubing.....If you have pipeline corrosion problems, a new 4-page folder tells how steel and plastic have been combined in the X-Tru-Coat pipe and tubing to meet severe corrosive conditions.
440B Republic Steel Corp.

Tubes, Duplex.....Bulletin 1954 is a 16 p. brochure giving properties, applications, etc. of Duplex Tube. 162 p. manual covers heat-exchanger and condenser-tube design, operation and application.
303 *Bridgeport Brass Co.

Tubing, Plastic.....Excellent chemical-resistant, all-purpose flexible plastic tubing. Sparkling clear, easy to clean, odorless, non-toxic, can be steam-sterilized. For details, request Bulletin No. 66.
322d *American Hard Rubber Co.

Tubing, Polyamide.....Outstanding characteristics and installation advantages of new flexible polyamide tubing are set forth in a 4-page bulletin that also includes instructions on installing.
440C Polymer Corp. of Penna.

Valve, Float.....Features of Cushioned Float Valves are explained in new 16-page technical bulletin W-5. Designed to control water level accurately, valves can be either quick opening or throttling.
440D Golden-Anderson Valve.

Valve, Pilot.....Spring-loaded, diaphragm-actuated hydraulic pilot valve that controls diaphragm valves on reducing or unloading service with extreme accuracy are detailed in new catalog sheet.
440E Atlas Valve Co.

* From advertisement, this issue

Valve, Pinch.....General and detailed information on the Flex Valve is found in new Catalog FL-1116. You will find all the information on each model that you need to make correct selection.
441A Farris Flexible Valve.

Valves.....There's an Ace Hard rubber, rubber-lined, or plastic-lined valve for every corrosion application. Diaphragm, gate and check types. Lists chemicals handled in Bulletin CE-52. Request your copy.
323b *American Hard Rubber Co.

Valves.....“Sentry” Models 1200, 1700, 1800, and 3000 are patented quick-closing latch type and quick-opening piston type. All are full flow valves. Full information available in Bulletin No. 500.
69 *Coppus Engineering Corp.

Valves.....Features: non-sticking; no metal-to-metal contact; needs no lubrication; requires no packing; renewable sleeve & plug. Details on type F valves available. Request a copy of Bulletin V/4b.
307 *Duriron Co.

Valves.....Company offers Stockham steel gate, globe, angle and check valves and Wedgeplug non-lubricated steel plug valves in carbon and special alloy steels. Details in Catalogs SV2 and W-1-56.
382 *Stockham Valves & Fittings.

Valves.....Vogt GP Valves are available in a complete range of sizes from ¼” to 2” and rated 800 pounds at 850°F. and 2000 pounds at 100°F. Full details in Supplement No. 1 to Catalog No. F-9.
236 *Henry Vogt Machine Co.

Valves, Butterfly.....Rubber lining of R-S butterfly valves protects entire valve body, gives you corrosion resistance with maximum economy. Complete line to meet your fluid control problems. Data.
338 *S. Morgan Smith Co.

Valves, Control.....Super 70 Series control valves offer: accurate response from topworks; greater stability through valve; self-actuating closure with float ring. Details available in Catalog 70-11.
115 Black, Sivalls & Bryson.

* From advertisement, this issue

For the latest developments in

Chemicals

Equipment

Processes

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Underwriters' Laboratories lists the Protectoseal “in-line” flame arrester vent for use within 50 ft. of the open end of vent lines.*

THIS “IN-LINE” TANK VENT PUT AN END TO DANGEROUS ROOF-TOP MAINTENANCE!

The above illustration shows the “in-line” vent located inside the tank house some 20 ft. from the open end of the line. This avoids frequent, costly and highly dangerous roof-top inspection formerly necessary where vents were installed outside at the end of the vent lines.

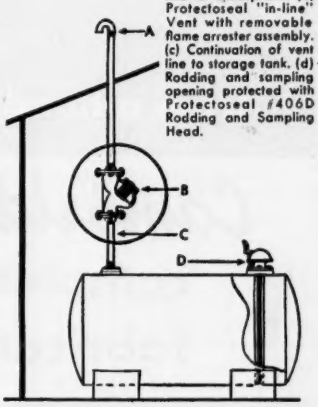
PROTECTOSEAL ENGINEERING SERVICES

The development of this “in-line” flame arrester vent is typical of Protectoseal design and engineering versatility. In providing proper fire and explosion protection, consideration is always given to the operating and maintenance problems of corrosion, sublimation, valve pressures, conservation of solvent vapors, cleaning of flame arresters and other special problems.

PROTECTOSEAL VENTING MANUAL

For a fuller understanding of how Protectoseal can help you solve your venting problems, fill out coupon below for your copy of the complete Venting Manual showing operating features and special applications of the complete Protectoseal line.

*The 1” in-line Flame Arrester Vent is approved for installations at distances up to 50 ft. from the open end of vent lines from flammable liquid storage and process tanks; 2” and larger sizes are approved for installation at distances up to 20 ft. from the open end of vent lines.



(a) Open end of vent line to atmosphere. (b) Protectoseal “in-line” Vent with removable flame arrester assembly. (c) Continuation of vent line to storage tank. (d) Rodding and sampling opening protected with Protectoseal #406D Rodding and Sampling Head.

Diagram shows actual installation of the Protectoseal “in-line” Flame Arrester Vent. Note how the vent is installed inside the tank house.

A COMPLETE LINE OF STORAGE TANK SAFETY EQUIPMENT

Conservation Type Vents

Non-Conservation Type Vents

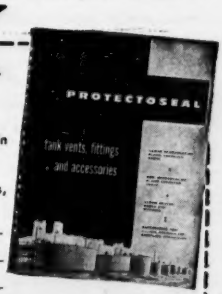
Rodding and Sampling Heads

Tank Truck and Tank Car Loading Covers

Storage Tank Fill Fitting

Working to prevent fires in cooperation with Underwriters' Laboratories, Inc., Associated Factory Mutual Fire Insurance Companies, National Fire Protection Association, Factory Insurance Association, Improved Risk Mutuals.

PROTECTOSEAL PRODUCTS PROTECT YOUR PLANT



The Protectoseal Company, Technical Service Department, 1948 South Western Avenue, Chicago 8, Illinois

Please send the Venting Manual with Price List and the Safety Bulletin Series as checked below:

☐ Protectoseal Venting Manual

☐ Safety Bulletin Series on “Flammable Liquids, their characteristics, hazards and safe handling”

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Company_____

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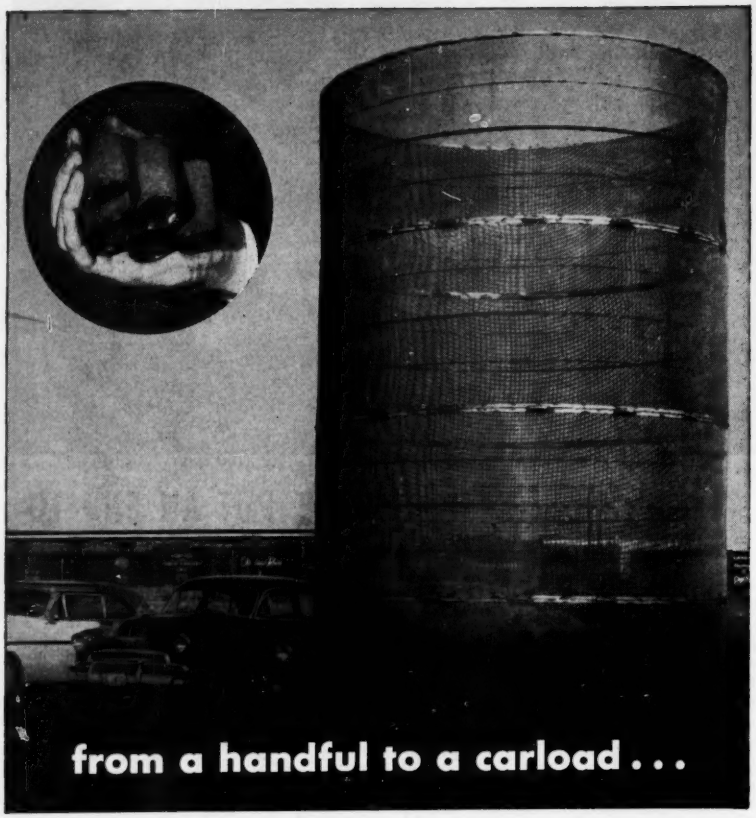

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LITERATURE . . .

Valves, Control.....New specifications S810-11 and S810-12 give details of construction on single and double seated Honeywell Series 800 diaphragm control valves. Include curves, dimensions.
441B Minneapolis-Honeywell.

Valves, Diaphragm.....Trouble-free plastic diaphragm valves—choice of general-purpose Ace-Ite, Ace Parian (polyethylene) or Ace Saran. Handles most corrosive chemicals & food ingredients. Bulletins 80 & 351.
322b *American Hard Rubber Co.

Valves, Diaphragm.....From antibiotics to the toughest acids, alkalis and salts, there is a combination of Hills-McCanna body and diaphragm materials that will best suit your needs. Request Valve Catalog 100.
321 *Hills-McCanna Co.

Valves, Diaphragm, Packless.....Eliminate steam leakage and maintenance on air,vacuum, gas, light oil and similar services. Available in wide selection of materials and sizes. See Folder AD-1942.
233 *Crane Co.

Valves, Drain.....Offers descriptive information on line of Strahman ram type valves . . . the only drain valves that cannot clog up. Made in any cast metal to meet your requirements. Request complete Catalog.
325 *Strahman Valves.

Valves, Metering.....For precision, flow control use this brass bar stock metering valve, equipped with an O-ring stem seal. Offers precise control—20 turns moves stem only ⅜". Bulletin BSV256.
T455 *Hoke Inc.

Valves, Plug.....Choose from Homestead Lever-Seald Plug Valves cast of metals and alloys to specification in sizes from 1" to 12"; for pressures from vacuum to 1500 lbs. See Reference Book 39-3.
107 *Homestead Valve Mfg. Co.

Valves, Pump . . . . . Durabla pump valves offer 7 new points of superiority. Feature tapered or V-shaped stud which screws down tight to the seat. Complete details available in new 8-page booklet CE-57.
345 *Durabla Mfg. Co.

Valves, Safety Relief.....Offer valuable features; economical "2 in 1" design; peak performance; absolute protection; maximum interchangeability. Full range of sizes and pressures available. Catalog No. 1900.
100 *Manning, Maxwell & Moore.

Valves, Solenoid.....Safety shut-off valve provides tight seating . . . large flow capacity. Ideally suited for use as safety shut-off valve on gas and oil fired furnaces, ovens and boilers. Details in Bulletin 8022.
131 *Automatic Switch Co.

Process Equipment

Agitating Equipment . . . . . Use Nettco Flomix to combine liquids and solids as they flow through a pipe line. Also offer side entering and portable and tripod models. Details available in Bulletins 531, 532, 551.
358 *New England Tank & Tower.

* From advertisement, this issue

Agitator, Drum.....Technical features of the new Prenco drum agitator in Data Sheet 2. Ready reference chart shows agitation time needed for full range of specific gravities in mixtures.
442A Prenco Products.

Blenders, Solids.....An 8-page data booklet on Tri-Rib blenders details features of these units whose performance is reported to shorten time needed to produce uniform blending of materials.
443A Bridges Engineering Co.

Blenders, Twin Shell.....Standard model Twin Shell for gentle mixing action. "Intensifier" for difficult-to-blend materials, "Liquid-Solids" blender for blending liquids into dry materials. See Catalog 14.
191 *Patterson-Kelley Co.

Centrifugals.....AT&M centrifugals are widely used in separation, dehydration, coating, filtering, impregnation and sedimentation processes. Maximum use of time and space, with top safety. "Centrifugal Force."
219 *American Tool & Machine.

Centrifuges.....Merco pressure centrifuge, new unit for continuous-centrifugal separations under pressure conditions. Accomplishes concentration, washing, soluble recovery, classification. Bulletin 2600.
142-3 Dorr-Oliver.

Cleaner, Portable.....The Hoffco-Vac high-vacuum portable cleaner described in new Bulletin M-135 was developed for non-stop operation on heavy dust deposits. It eliminates health hazards.
443B U. S. Hoffman Machinery.

Compacting Process.....Compacting mill densifies fines into flakes. Flakes granulated in roller mill. Final separation made in gyratory screen, 70 to 80% recovery of salable product. Bul. 25C6177J.
227 *Allis-Chalmers Mfg. Co.

Crushers.....Gruendler equipment for performance shredding, hogging, secondary grinding and refining of wood, wood wastes, barks and similar organic materials. Bul. 930.
*Gruendler Crusher & Pulverizer.
BL466

Crushers.....Hard hitting giant with high speed impeller bars strikes material in suspension . . . continues to wallop it until it's broken down to the desired size. Full details in Bulletin 854.
128 *Jeffrey Mfg. Co.

Crushers, Cone.....Symons Intermediate Cone Crushers are efficient in secondary reduction crushing of hard rock, gravel, ores and industrial minerals. Offer long life of heavy duty service. Bulletin 236.
443C Nordberg Mfg. Co.

Crushers, Jaw.....Cast, steel, frame, manganese jaw and check plates. Large diameter shafts reduce shaft deflection and thus increase life of roller bearings in bumper. Full details in Bulletin C12-B12.
352c *Denver Equipment Co.

Crushers, Sample ..... Does the job quickly and efficiently. There is no loss of moisture content in sample. Any amount—from 0 to 20%—in one operation. Company makes literature available upon request.
B468 *American Pulverizer Co.

* From advertisement, this issue

IS YOUR PROBLEM:

WEAR plus severe CORROSION?

Then you'll be interested in investigating Kennametal* Grade K501

Kennametal Grade K501, a platinum bonded tungsten carbide, was developed especially to meet conditions where severe abrasive conditions as well as corrosive agents are encountered. While K501 equals the corrosive resistance of the noble metals, it is lower in cost, and has a much higher resistance to wear.

Here are results of laboratory corrosion tests, showing comparisons with other metals which were developed specially for corrosion resistance:

SOLUTION	STRENGTH % by WT.				TEMPERATURE				LOSS† mg/dm/d			
	Kennametal K501	Monel Metal	Hastaloy B	Kennametal KM	Kennametal K501	Monel Metal	Hastaloy B	Kennametal KM	Kennametal K501	Monel Metal	Hastaloy B	Kennametal KM
Nitric Acid (HNO_3)	5	Above 1	—	5	Boiling	Above 80°F	—	Room	0	Not	—	587
Sulfuric Acid (H_2SO_4)	5	Above 20	10	5	Boiling	Boiling	Boiling	Room	0	Recom-	85	161
Hydrochloric Acid (HCl)	1.25	All	10	5	Boiling	Above 120°F	Boiling	Room	74	mended	77	245

†Tests of one week duration

Note: The above tests are indicative of what may be expected in service, but it is recommended that specific tests under specific conditions be made.

In addition to its unusual abrasion and corrosion resistance properties, Kennametal K501 has a Hardness of 91.8 Rockwell A, Transverse Rupture Strength of 125,000 psi, and a Specific Gravity of 15.50. These unique properties suggest its use in valve parts, nozzles, seal rings, balls, non-lubricated guides and bushings, and other parts exposed to strong mineral acids, fuming nitric acid, and similar highly corrosive agents.

Made by Kennametal's exclusive methods of powder metallurgy, K501 can be produced in many complex shapes to close tolerances to meet the requirements for specific parts. It can be fastened by brazing.

Why not investigate Kennametal K501? It may be the answer to your problem. Write KENNAMETAL INC., Dept. CE, Latrobe, Pennsylvania.

*Kennametal is the trademark of a series of tungsten and titanium carbides which have exceptionally high resistance to the destructive forces of abrasion, corrosion, erosion, deflection, deformation, high temperature oxidation and impact.

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check these special features

*available with Yeomans Vertical Wet Pit Centrifugal Pumps**

sand glass particles and other abrasives	*Lubri-Vac*® reduces by 95% the failure of bearings due to scoring by abrasive particles. Lubri-Vac constantly flushes bearings with lubricant, keeps foreign matter away. (An exclusive Yeomans feature included on all heavy-duty pumps.)
ash fly ash cinders bits of coal corn foots and other solids contained in drainage	A cradle pump with protective sleeves to protect shaft. Special manganese steel parts. Yeomans pumps including these features will give long life under the most severe abrasive conditions.
potassium cyanide sulphuric acid jet fuel melted naphthalene and other toxic or volatile liquids	Shaft seal is not under liquid pressure with Yeomans Vertical Wet Pit Pumps. This feature eliminates the leakage hazard which is present with horizontal pumps.
molten phosphorous acetic acid hydrochloric acid black liquor and other corrosive liquids	Whatever the corrosive and/or abrasive liquid to be pumped—Yeomans has special ferrous and non-ferrous alloy parts to handle it.

*Vertical Wet Pit Centrifugal Pumps save floor space, require no priming —no costly liquid leaks as stuffing boxes are not under liquid pressure. Capacity range from 5 g.p.m. to 10,000 g.p.m.

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LITERATURE . . .

Deaerators.....Six bulletins cover: why and how of deaeration; specific application of the Jet-Tray, Tray Type, Atomizing Deaerator, Surface Type Deaerating Hot Water Heater and Cold Water Deaerator.
379 *Cochrane Corp.

Demineralizer, Water.....Technical reprint T-153 discusses the role that demineralizer subfill plays in reducing costs of operating a demineralizing system. Details on rinse requirements.
444A Graver Water Conditioning Co.

Dryer Cylinder, Air.....Material: carbon steel—Thickness: head, 2"-Shell 2⅞"—Design pressure: 3200psi—Hydrostatic test pressure: 5400psi—Design temperature: 450°F. For complete details, see bulletins.
14 *Downingtown Iron Works.

Dryer, Multi-Louvre.....Multi-Louvre dryers and how they work are described in new 16-page book 2609. Typical layouts, dimensional data and a 2-page psychrometric chart aid your evaluation.
444B Link-Belt Co.

Dryer, Rotary.....How granular solids are dried without loss of fines is described in Bulletin RDB-101 on the Carpco Dual-Flow dryer. Unit comes complete with all auxiliary equipment.
444C Carpco Mfg. Co.

Dryer, Rotary.....Single-sheet Bulletin RDB-101 gives design, construction and other important details of new dual-flow rotary dryer. Models described are units that evaporate 200 or 400 lb. of water/hr.
444D Carpco Mfg. Co.

Dryer, Spray.....All drying needs are reported satisfied with a new pilot plant spray dryer described in Bulletin 431. Easy addition of accessory equipment lends versatility to unit.
444E Proctor & Schwartz.

Dryers.....Lectrodryers can dry air and gases in volume to dewpoints below —100°F—can drop relative humidity lower than 10%. "Because Moisture Isn't Pink" describes drying installations in industries.
70 *Pittsburgh Lectrodryer Co.

Dryers & Calciners.... For pilot plant work, 12-page Bulletin 117 illustrates and describes new line of gas-fired and steam-heated continuous rotary dryers and other equipment of this type.
444F C. O. Bartlett & Snow Co.

Dryers, Spray.....Nerco-Niro sets the pace in design and drying performance for processing requirements. You can dry more, in less time, with closer product control. Full details in Bulletin No. 226.
426 *Nichols Engrg. & Research.

Dryers, Vacuum.....Faster, uniform heat transfer plus rapid vapor removal . . . means today's best in vacuum drying with the Patterson Conaform. Full details made available in Bulletin No. 5611-1.
327 *Patterson Foundry & Mach.

* From advertisement, this issue

Dust Collectors.....Pangborn collectors trap dust at the source, clean so thoroughly that in the winter many firms cut heating costs by recirculating the already-heated, cleaned air. Bulletin 922.
347 *Pangborn Corp.

Dust Filters.....28 p. book explains in detail the distinguishing features of reverse jet filters. Contains schematic operating diagrams, performance curves for various types of dust. Request Bulletin 559.
422a *Day Co.

Dust Filters....."Type RJ" dust filter is an economical, high efficiency, automatic-continuous dust filter which can be furnished for pressure or vacuum operation. Full details available in Bulletin 560.
422b *Day Co.

Dust Separators.....Exclusive Day design provides high efficiency with low horsepower requirements. For complete details on Dual-Clone dust separator, company makes available new Bulletins 49DC and 576.
422c *Day Co.

Filter Fabrics ..... The right fabric adds efficiency to continuous operation. Announces availability of a fully illustrated booklet. "Filter Fabric Facts," describing filter fabric development and application.
108 *Wellington Sears.

Filter, Vertical Pressure.....Publication 6321 furnishes details of operation, available sizes and filtering capacity for the Standard type C vertical pressure filter for water clarification.
445A Cochrane Corp.

Filters, Ceramic.....Specifications, illustrations, installation and operating data for ceramic vacuum filters in four different materials of construction are included in newly issued 4-page bulletin.
445B General Ceramics Corp.

Filters, Disc.....Special patented design of segments in filters use both gravity and vacuum to give a drier filter cake. Drainage is complete and positive with no blow-back. Details in Bulletin FG-B1.
352d *Denver Equipment Co.

Filters, Vacuum, Rotary, Continuous .....The Original String Discharge Filter is only one of many types of FEinc continuous rotary vacuum filters available . . . custom-made at standard costs. Bulletins.
312 *Filtration Engineers.

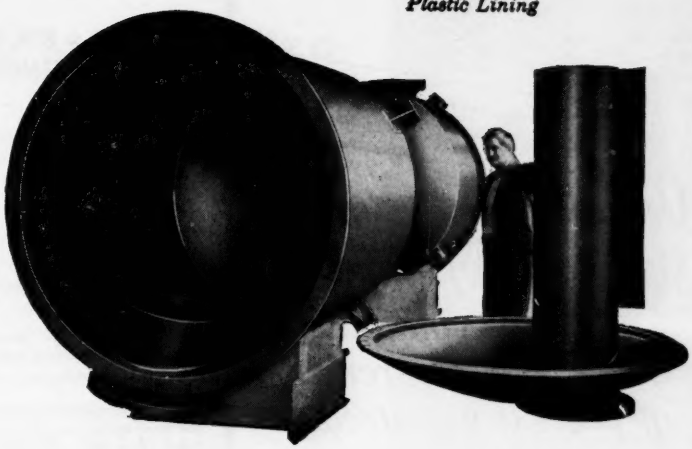
Filters, Valveless.....New bulletin, "The Permutit Valveless Filter," includes details, drawings, operating conditions, capacities. Completely automatic gravity filter. Costs less than manual unit.
226C *Permutit Co.

Filters, Water.....Booklet "Fulflo Filters for Water and Aqueous Liquids" contains technical data on each filter model. Wide range of controlled filter densities aids selection for best results.
445C Commercial Filters Corp.

Filtration Units, Air.....Rollotron Booklet gives facts about the new air filtration unit that eliminates scheduled filter maintenance. Offers ultimate in efficiency—electronically clean air. Bul. 249.
211 *American Air Filter Co.

* From advertisement, this issue

Pulp Tank prepared for Plastic Lining



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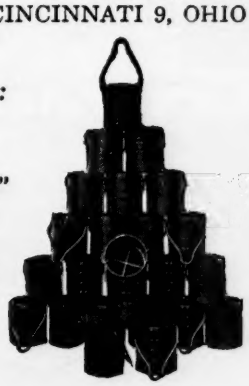

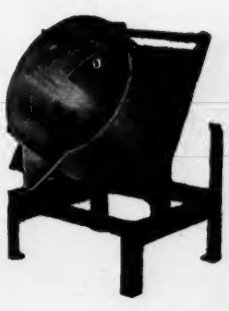

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Arnold O. Beckman Gas Density Balance

...for continuous, accurate measurement of process gas streams

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HERE ARE A FEW OF ITS MANY OUTSTANDING FEATURES . . .

Ranges: Single or multiple ranges with spans from 0.05 to 5.0 sp. gr. relative to air.

Rapid Response: 95% of any reading in less than one minute.

Sensitivity and Accuracy: ± ½% of full scale.

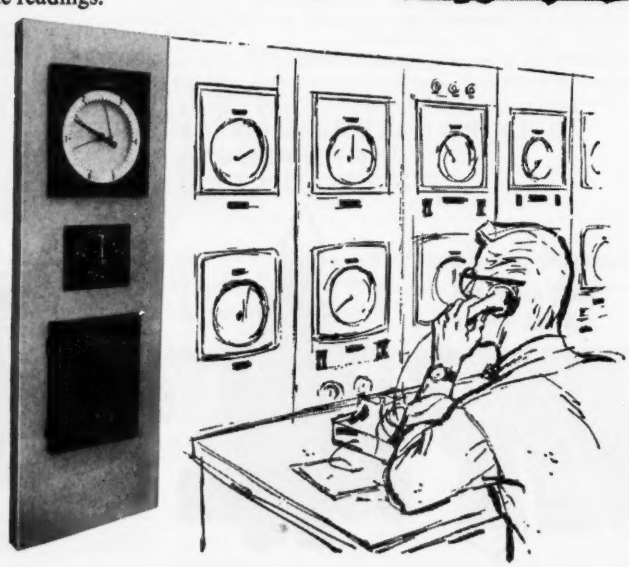
Corrosion Resistant: Measuring element protected against corrosive elements.

Output: 0-5 millivolts standard for use with potentiometer type recorders. Current or pneumatic output available with instruments having single ranges, or two or more ranges having a common end point.

Sample Required: 48 cubic inches per minute at 10 psi.

Power Required: 130 watts with 115 volts, 60 cycles.

The Arnold O. Beckman Gas Density Balance is a single compact unit, designed for wall or flush mounting. The standard steel case is vapor tight, thermally insulated and controlled so that operation is unaffected by ambient temperature changes. The unit weighs about 65 lbs. Explosion-resistant cases are also available.



For more information on the Model 3A Density Balance write directly for Data File 22X-57

Arnold O. Beckman INC.

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Flotation.....More large plants are installing "Sub-A's" for entire flotation job, because they give maximum recovery at a low cost per ton. Simplified continuous operating. Details in Bulletin F10-B81.
352e *Denver Equipment Co.

Generators, Inert Gas.....Assure a safe, dependable supply of chemically clean inerts. Deliver inerts at a special analysis . . . without fluctuations. For facts and technical data, request Bulletin No. 1-10.
283 *C. M. Kemp Mfg. Co.

Grinding Machine . . . . . Sturtevant Micronizer grinding machines give greater finenesses than tube or roller mills. Feature: no moving parts; instant accessibility; easy cleaning. Micronizer Bulletin.
216 *Sturtevant Mill Co.

Gyradisc.....The Nordberg Gyradisc uses the Gruendler method of reduction. It is a revolutionary machine for the production of large tonnages of extremely fine products. Full details in Bulletin 228.
446A Nordberg Mfg. Co.

Homogenizers, Laboratory.....Laboratory homogenizers available on rental basis. Machines for exploring new Gaulin dimension of particle control for improved mixing. Bulletin LH-55.
382 *Manton-Gaulin Mfg. Co.

Kilns, Rotary.....Made for the individual installation, Traylor rotary kilns have been built to 12'0" in diameter and to 450'0" in length. Company makes complete details available in Bulletin 11-121.
20 *Traylor Engrg. & Mfg. Co.

Lubricators.....Designed to safeguard your expensive machinery with positive force feed lubrication. Choice of models to meet any need, with fully adjustable pumping rate. Details in complete catalog.
335 *Manzel Div.

Mills.....14" x 30" and 10" x 22" sizes are for large production, the 5" x 12" provides economical production of small batches, and the 4" x 8" mill is specifically designed for lab use. See Bulletin 456-A.
447 *J. H. Day Co.

Mills, Ball.....A steel-head ball mill will suit your particular need. Five types of discharge trunnions. All-steel construction. Low initial cost due to quantity production. Details in Bulletin B2-B13.
352b *Denver Equipment Co.

Mill, Hammer.....Catalog 907 illustrates and describes Ridgid hammer type shredders, grinders and hashers. Included are details of construction and operation, dimension drawings and specifications.
446B Jeffrey Mfg. Co.

* From advertisement, this issue

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Mills, Hammer.....Crushes, grinds, shreds to finished size in one operation; reduces production costs up to 50%; saves up to 75% on equipment cost. Company makes details available in complete catalog.
367 *Williams Patent Crusher.

Mills, Imp.....Raymod imp mill is equipped to handle almost any combination of pulverizing, blending, classifying, conveying and/or drying operation. For complete details, request Catalog 77.
234 *Raymond Div.

Mills, Tube.....For wet grinding . . . titanium pigments, manganese dioxide, diatomaceous earth, limestone; for dry grinding . . . silica flour, gypsum, carbon black, pigments, cement materials. Bul. 18-B-11.
424 *Hardinge Co.

Mixers.....Describes Super Agitators and Mixers. Patented stand-pipe around propeller shaft assures positive agitation. Patented wearing plate prevents sand-up on shutdown. Request Bulletin A2-B4.
352a *Denver Equipment Co.

Mixers, Dispersall.....This mixer disperses, mills and blends (as well as emulsifies) in one operation. Eliminates premilling and premixing. Gives you speed and power, plus easy cleaning. See Catalog 78.
L448 *Abbe Engineering Co.

Oil Purifiers, Centrifugal.....Various model DeLaval centrifugal oil purifiers and their particular applications are discussed in new Bulletin OP-109. Capacities of each machine are included.
447A DeLaval Separator Co.

Ozone Generators.....Brochure "Ozone Generation for Industrial Application" covers equipment, sizes, capacities, auxiliaries, power needs, costs data, installation and dimension data.
447B Welsbach Corp.

Pilot, Temperature or Pressure..... Scope of applications is well beyond the range of ordinary pilots for flexibility and accuracy, and compares favorable with much more expensive controllers. Catalog.
355 *U. S. Gauge Div.

Presses, Dewatering.....A battery of Davenport 1B continuous presses dewatering waste paper pulp in the manufacturing of paper shipping containers. Company makes full details available in Catalog A.
B459 *Davenport Mach. & Fndry.

Presses, Filter.....Shriver has a long record in solving problems of filtration, washing, extraction or thickening, with the kind of filter press best suited to specific conditions. See data book.
429a *T. Shriver & Co.

Presses, Filter.....Sperry Catalog, complete with charts, tables, and diagrams, will help you in the operation, maintenance and selection of filtration equipment. Request your copy of Catalog 7-E.
431 *D. R. Sperry & Co.

Process Equipment.....Broad range of process equipment described in "An Outline of Progress" includes units for every mixing, blending, size reduction and materials handling application.
447C Strong-Scott Mfg. Co.

* From advertisement, this issue

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There's a DAY three-roll mill that is exactly right for your requirement. The 14" x 30" and 10" x 22" sizes are for large production, the 5" x 12" provides economical production of small batches, and the 4" x 8" mill is specifically designed for lab use.

To provide dispersions of the highest quality, every DAY mill has been precision engineered and carefully manufactured to insure maximum rigidity, ultra-smooth operation and long life. In addition, DAY Hydra-Set, the most advanced and accurate roll setting mechanism, is available as optional equipment on new production models or as a field conversion kit.

Whether you mill paints, inks, plastisols, pastes or similar products, standardizing on DAY mills, from lab to full production, helps you achieve production economies and product improvement. Lab facilities are available to test your product.

One fine example of the many companies enjoying these benefits is The Patterson-Sargent Co. of Cleveland, Ohio. They have found it pays to standardize on DAY roll mills because they are dependable and give greater production at lower operating costs. Write today for Bulletin 456-A.

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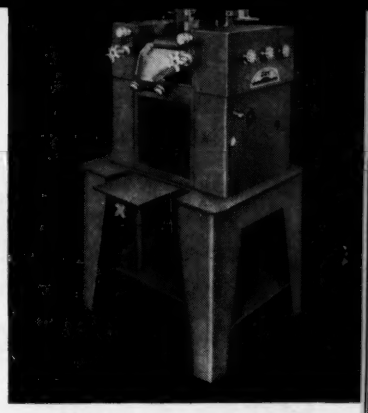
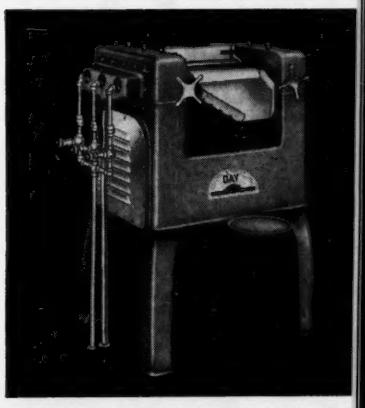
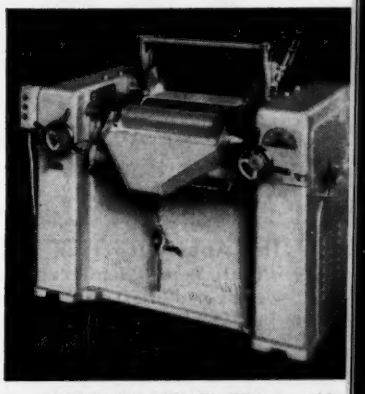


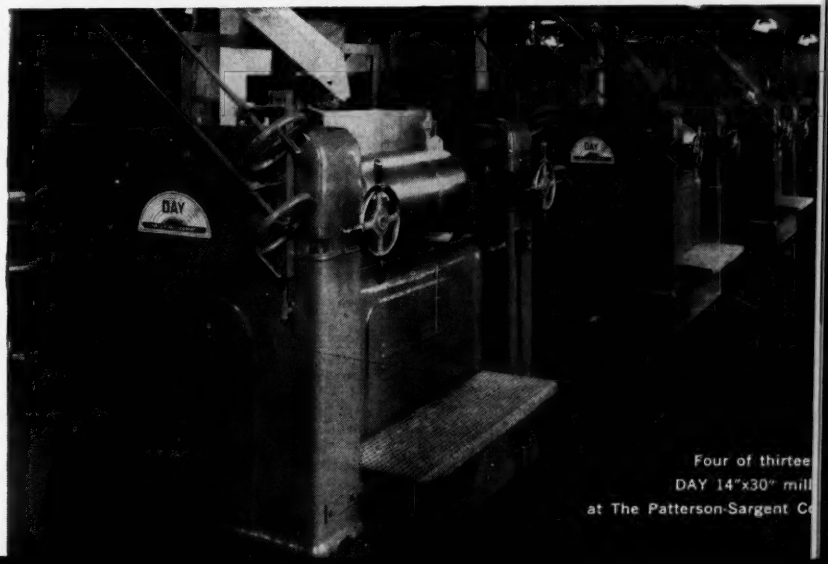
DAY 4"x8" mill for your laboratory



DAY 5"x12" mill for your small batches



DAY 10"x22" mill with lift-type guides



Four of thirtee
DAY 14"x30" mill
at The Patterson-Sargent C

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LITERATURE . . .

Propellers, Fabricated . . . . . "Fabricated" propellers will do a perfect job of mixing, blending, stirring, pumping or aerating in applications requiring relatively low horsepower and not over 1750 LPM. Catalog. TR466 *Michigan Wheel Co.

Reactors, Continuous.....Votator continuous reactor controls heat of reaction for processing viscous and heat sensitive materials. Low cost operation from rapid heat transfer rate. Bulletin V250. 2 *Girdler Co.

Reactors, Stainless Steel.....Pfaudler designs include such features as—heavy duty drives, properly engineered agitation systems, rotary seals or stuffing boxes, baffles, thermometer wells, etc. Brochure 944. 476 *Pfaudler Co.

Samplers, Automatic.....Heavy duty units, extra rigid track and ball-bearing wheels assure positive travel and timing of sample cutter. Available in stainless steel. Full details available in Bulletin S1-B4. 352g *Denver Equipment Co.

Screening Equipment.....Company offers screens for every water, sewage and industrial waste: coarse screens for removal of large solids and fine screens for removal of small solids. Book 2587. 448A Link-Belt Co.

Screens.....Symons V Screen is specifically designed for fine screening. Multiplies screening action by combining centrifugal and gravitational forces. Full details are available in Bulletin No. 243. 448B Nordberg Mfg. Co.

Screens, Vibrating.....Gives fast, clean separation without blinding. Even, smooth flow of material because of patented "true-circle" eccentric action. Full details available in Bulletin S3-B11. 352h *Denver Equipment Co.

Screens, Vibrating.....Complete information on the Sweco screen separator is featured in a new 22-page catalog, S-56-1. Reader will find operating and application data for many process industries. 448C Southwestern Engineering Co.

Separator, Liquid-Gas.....How the Selas Liqui-Jector removes entrained liquids and solids from air, gas and steam systems is explained in new Bulletin S-1052. Three models up to 7.000 scfm. 448D Selas Corp. of America

Separators, Entrainment.....If liquid entrainment is a contributing factor in design or operation, Metex Hi-Thruput Mist Eliminators will assure greater production and improved quality of yield. Bul. ME-6. 329 *Metal Textile Corp.

Strainers, Line.....Remove dirt, scale, rust and other solids from liquids flowing in any pipe line system. Protects and prolongs life of pumps, meters, loading valves, etc. Full details in Bulletin F-36. 16a *Jordan Corp.

Tanks, Mixing.....How construction of Pfaudler mixing tanks makes them fast in operation, sturdy and easy to clean is told in Bulletin 941. Capacities and dimensions are given. 448E Pfaudler Co.

* From advertisement, this issue

Solvents Have Nine Lives Too?

'Course they do! Vaporized solvents can be used again and again! Witchcraft? No, solvent recovery does the trick.

Solvent recovery is the efficient, economical way to recover solvents vaporized in manufacturing processes. What solvents? Count 'em: alcohols, esters, ethers, ketones, hydrocarbons, chlorinated compounds and practically all mixtures of these solvents can be recovered and reused. And look at these vital statistics . . . efficiency—more than 99%: cost—1 to 2¢ per pound.

Here's how solvent recovery works. Vapor laden air is drawn from the evaporation process and passed through a bed of activated carbon. The solvent vapor is adsorbed on the carbon and the denuded air is discharged into the atmosphere. When the carbon becomes saturated, the vapor laden air is switched to a second adsorber.

Then, low pressure steam drives the solvent out of the carbon bed and the steam-solvent mixture is condensed. If the solvent is insoluble in water, an automatic decanter separates the mixture. If the solvent is water-soluble, distillation does the job.

CARBIDE has much more information on how a COLUMBIA Activated Carbon Solvent Recovery system can recover your process solvents. Write now!

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30 East 42nd Street UCC New York 17, N. Y.

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Traps, Power.....Offer magnetic, pneumatic, automatic action to: free air and gas lines of entrainments, assist air and gas dehydrating equipment, discharge condensate. Bulletin 501.
449A Hankison Corp.

Testing, Laboratory.....Testing laboratory facilities for complete batch or pilot tests. Ample test facilities for investigations on crushing, grinding, mixing, classification, separation, etc. Bulletin T4-B15.
352j *Denver Equipment Co.

Thickeners.....Enclosed, running-in-oil tread motion, Patented spiral rakes move settled solids to center discharge with continuous motion, rapid removal of solids tends to eliminate overload. Bul. T5-B5.
352i *Denver Equipment Co.

Wash Collector, Centrifugal.....Ducon centrifugal wash collector, Type UW-4, is a basic air scrubber with applications for the wet principle collection of problem dusts and recovery fines. Bulletin W-7456.
339 *Ducon Co.

Waste Treating Equipment.....All water and waste treating equipment manufactured by Infilco is covered in new Bulletin 80 entitled "Products and Processes." Cross-references given for bulletins.
449B Infilco, Inc.

Wire Cloth.....90 p. catalog describes company's facilities for fabricating wire cloth parts. Wire cloth parts for screening, filtering and special uses. Provides useful metallurgical data. Request your copy.
442 *Cambridge Wire Cloth Co.

Pumps, Blowers, Compressors

Air Duct, Flexible.....How Wiremold flexible air duct is used for air conditioning, fume and dust exhaust and corrosive fumes is told in a new 4-page circular, Form 591, now available.
449C Wiremold Co.

Compressors.....Describes Allis-Chalmers single and two-stage vane type compressors for shop air, gas handling, drilling and numerous other applications. Bulletin Nos. 16B8244 and 16B8126.
365 *Allis-Chalmers Mfg. Co.

Compressors, Centrifugal.....Elliott makes a complete line of single- or multi-stage centrifugal compressors, turbine or motor drive, for handling air or gases. Full details available in Bulletin P-7.
210D *Elliott Co.

* From advertisement, this issue

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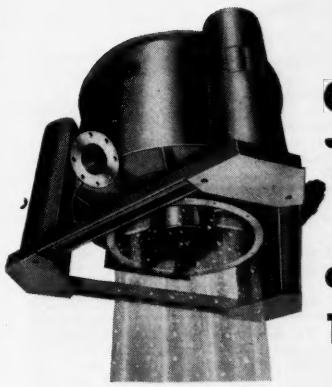

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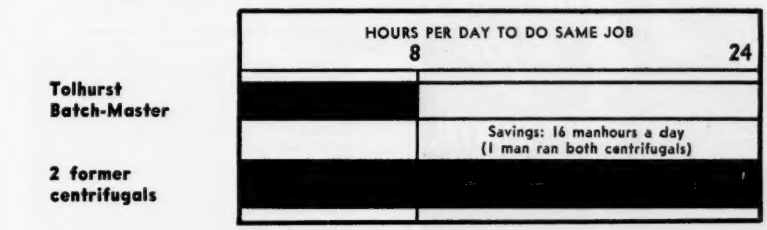
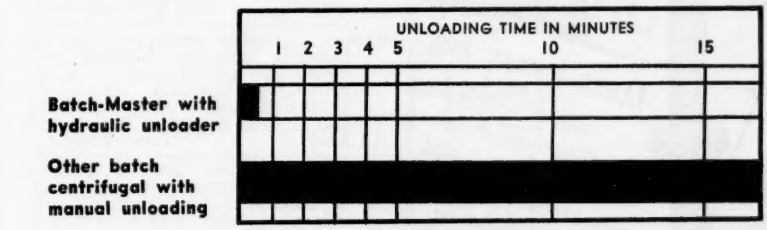
centrifugal saves
16 manhours a day

A Tolhurst Batch-Master centrifugal is now processing the same volume of fine organics in 8 hours as 2 other centrifugals formerly did in 24 hours. These results, illustrated graphically, occurred in a leading chemical plant.



Unloads in 30 seconds

Tolhurst's hydraulic unloader and bottom discharge unload the solids in 30 seconds. Other batch centrifugals, under identical conditions, take 15 minutes or more.


UNLOADING TIME IN MINUTES
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Batch-Master with hydraulic unloader
Other batch centrifugal with manual unloading

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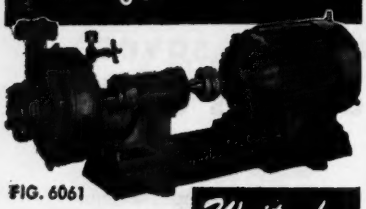

FIG. 6061

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Fig. 19,488

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LITERATURE . . .

Fans.....New Type "FG" offers excellent chemical resistance to a wide variety of acids, salts, gases, organic materials and other corrosives. Suitable for temperature applications to 225° F. Bull. FI-511.
136 *Buffalo Forge Co.

Fans, Exhaust.....High air delivery per horsepower required. Statically and dynamically balanced; designed exclusively for dust control applications. Company makes complete details available in Bull. 471.
422d *Day Co.

Pump, Turbine.....Expanded line of Miniturb turbine pumps is described in new 4-page Bulletin 4701-D. New sizes permit greater selection and wider application for this vertical turbine pump.
450A Deming Co.

Pumps.....Available in aluminum, bronze, stainless steel, Hastelloy and titanium, Aldrich fluid ends handle all types of liquids—nitric acid, caustic solutions, fatty acids, etc. Details in Data Sheet 100.
86 *Aldrich Pump Co.

Pumps . . . . . Rubber permanently bonded to the impeller and all liquid passages prevents the corrosion that could quickly put an ordinary metal pump out of action. Complete details available in Bulletin 982.
80 *Buffalo Pumps.

Pumps.....Handle most anything that can pass through a pipe, from free-flowing liquids to non-pourable pastes—materials containing relatively large particles or abrasives. Details in Bulletin 30-CE.
279 *Robbins & Myers.

Pumps....."How to Solve Pumping Problems" presents a general explanation of rotary gear pumps, factors of pumping problems, sample problems and technical data. Full details in Form 3060.
450B Geo. D. Roper Corp.

Pumps.....Taber pumps are built for handling chemical solutions, efficiently and economically . . . in the processing industries. Details on horizontal pumps in Bulletin C-355, and vertical pumps in Bull. V-837.
L450 *Taber Pump Co.

Pumps.....If you have a problem where metering, blending or other accurate pumping of liquids is concerned let Viking help solve it. Use Viking pumps for accurate pumping. For information, Bulletin 57Sc.
T461 *Viking Pump Co.

Pumps.....Warren can build the pump to do the job . . . 50 SSU or 500,000,000 SSU. Offers these types of pumps —reciprocating, centrifugal and gear-screw. Company makes full details available in bulletins.
437 *Warren Pumps.

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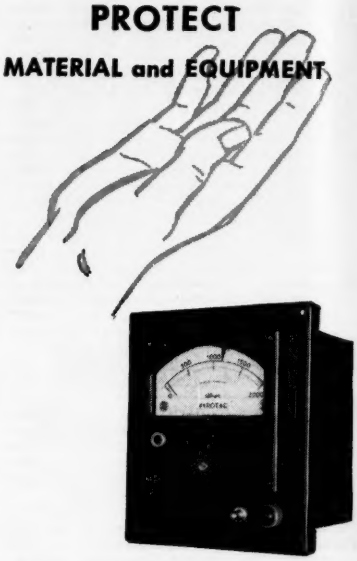

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PRECISION INSTRUMENTS FOR EVERY INDUSTRY

Pumps, Centrifugal.....Several bulletins cover Warren centrifugal pumps. They are: Bulletin 225, Bulletin 227, Bulletin 236, Bulletin 240, Bulletin 241, Bulletin 246, Bulletin 248. All revised.
451A Warren Pumps Inc.

Pumps, Centrifugal.....Vertical wet pit centrifugal pumps save floor space, require no priming—no costly liquid leaks as stuffing boxes are not under liquid pressure. Full details available in catalog.
444 *Yeomans.

Pumps, Glassed.....Remarkable new Goulds-Pfaudler glassed pumps resist corrosion just as laboratory glassware does. Available to provide operating advantages and economies. See Bulletin 725.2.
48-9 *Goulds Pumps.

Pumps, High Pressure.....Warren six stage, type TH, high pressure pumps feature: modern casing design, semi-centerline support, lowest maintenance, radial bearing, tested performance, etc. Bul. 244.
451B Warren Pumps Inc.

Pumps, High Vacuum ..... Catalog covers: industrial and scientific applications, types of vacuum systems, operating mechanism, vibration elimination, gas ballast, discharge valves, etc. Catalog 425A.
203 Kinney Mfg. Div.

Pumps, Industrial.....Jabsco Industrial Pumps; instantly self-priming; simple, compact, only one moving part; durable neoprene impeller; self-lubricated; trouble-free operation. Catalog sheets available.
T462 *Jabsco Pump Co.

Pumps, Piston.....Warren realwear horizontal duplex steam pumps for boiler feed, fuel oil pressure, oil transfer, general water service, and a variety of other services. Request Bulletin 230 revised.
451C Warren Pumps Inc.

Pumps, Piston-Diaphragm ..... For controlled - volume pumping of fluids. Flow-charts, typical applications and specifications and models of various capacities and constructions in Bulletin No. 440.
125 *Lapp Insulator Co.

Pumps, Proportioning.....Mode 1106 Proportioneer feeds all chemicals (alkaline, neutral, or acid) accurately (guaranteed within ±1%) over 15 to 1 range. Full details made available in Bulletin 1106-2.
326 *Proportioneers, Inc.

Pumps, Rotary.....Catalog covers rotary pumps for manufacturing, marine, petroleum, process industries and hydraulic pump motors for high torque, low speed, power transmission. See Catalog 957.
451D Geo. D. Roper Corp.

Pumps, Sand.....Rubber lined sand pumps lower pumping costs 30% to 70% due to simple design, lighter weight and accuracy of rubber parts which increase efficiency 1½ to 3 times over other sand pumps. Bul. P9-B8.
352f *Denver Equipment Co.

Pumps, Sump.....Centrifugal sump pumps—Types VS and VN—wet and dry pit types for clear liquids, sewage and other liquids containing solids. Eight sizes offered. Request Bulletin WQ-220.
451E Warren Pumps Inc.

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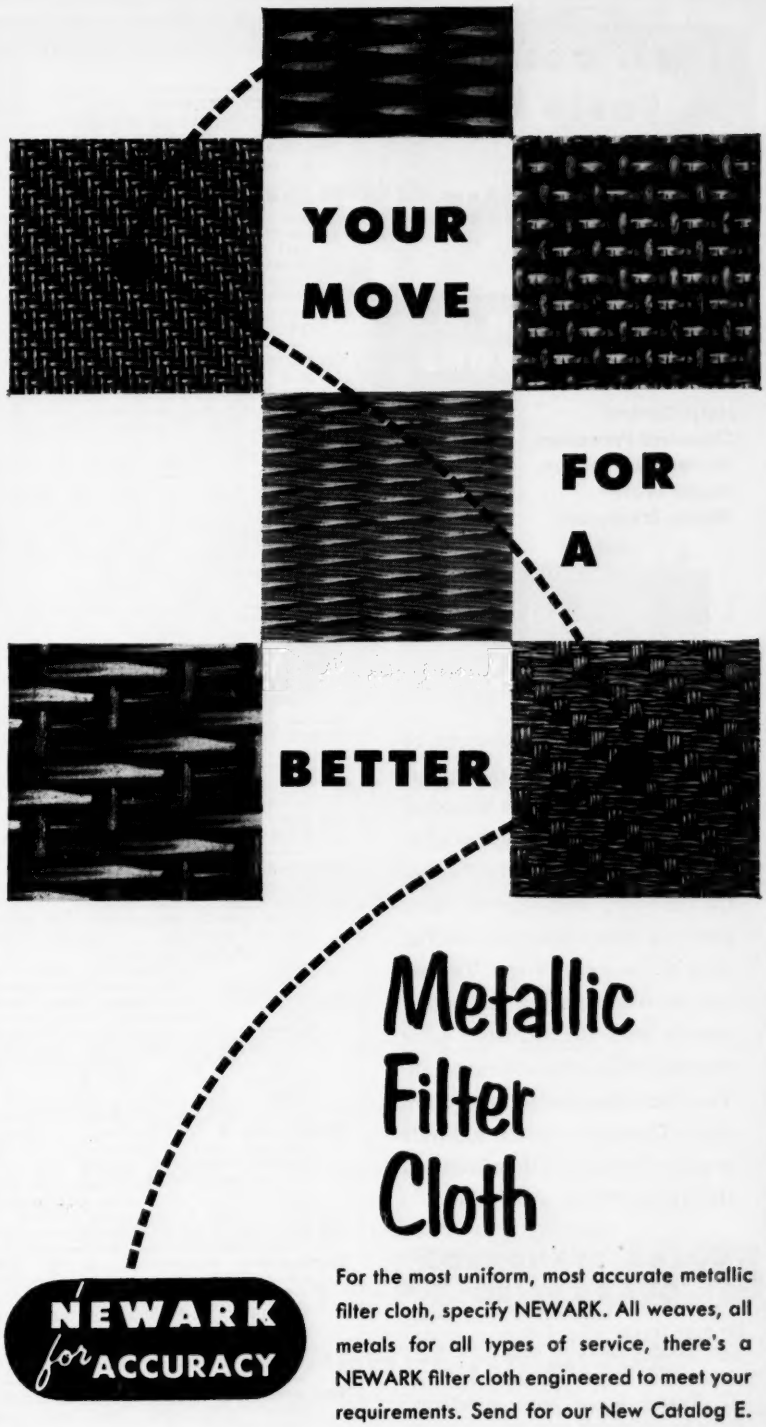
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LITERATURE . . .

Smokestack, Glassed Steel.....How Permaglas smokestacks lengthen life and lower cost is discussed in new Bulletin SS-202. Compared to other lined stacks, protection lasts three to five times longer.
452A A. O. Smith Corp.

Snubbers.....Stops noise from intake and exhaust of air, etc., and stops pulsation caused by line surges from compressors, pumps, and blowers. Company offers complete literature on pulsation snubbers.
T467 *Burgess-Manning Co.

Ventilators, Fume.....Report "Corrosive Fume Ventilation Equipment" illustrates and covers recommended exhaust rates, procedures, air flow charts, types of systems and equipment.
452B Heil Process Equipment Corp.

Vents.....Complete Venting Manual shows operating features and special applications of complete Protectoseal line. "In-line" vent avoids frequent, costly and highly dangerous roof-top inspection.
441A *Protectoseal Co.

Services, Processes, Misc.

Cleaning, Chemical.....Report discusses nature of soils usually encountered in chemical processing equipment, and the Oakite compounds developed to remove them. Request Service Report B-6039.
L458 *Oakite Products.

Electrochromatography.....6 p. illustrated brochure describes operation of electrochrometography set and gives specific suggestions for processing proteins, inorganic ions, large particles, viruses.
452C Michrochem. Spec. Co.

Electron-Beam Processing, High Voltage.....Penetrating radiation is being used in a number of projects —preservation of foods, sterilization of drugs, cross-linking of plastics, etc. Bulletin E.
452D High Voltage Engineering.

Engineering & Construction.....Engineering and construction of refineries, chemical plants and ore beneficiating mills . . . design and manufacture of process equipment. Full details in Brochure E-3-32.
82 *Southwestern Engineering Co.

Engineering Service.....14 p. brochure describes this company's administrative, engineering and production services for supplying customers with lower cost, better quality production parts.
452E New England Prod. Co.

Extinguishers, Fire . . . . . Company offers these types; foam soda-acid clear water anti-freeze; cartridge-operated dry chemical; pressurized dry chemical; squeeze-valve carbon dioxide; trigger carbon dioxide. Bul. P-8.
435 Walter Kidde & Co.

Fluid Coking.....12 p. booklet describes a continuous coking process developed by this company. Sections on process flow, feed stocks, product yields and quality, economics, installations.
452F Esso Research & Eng. Co.

* From advertisement, this issue

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Isomerization Process.....8 p. illustrated brochure describes new isomerization process for upgrading pentanes and hexanes. Flow sheet and processing scheme point out economic advantages.
453A M. W. Kellogg Co.

Pulping Equipment.....Bulletin entitled "Laboratory Equipment for the Pulp and Paper Industry" describes the equipment items in a complete line of this specialized equipment now offered in the U. S.
453B Mertecfelt Corp.

Radiation Protection.....4 p. bulletin 407 describes services for health and safety precautions against hazards of radioactivity. These include accountability, criticality precautions.
453C Nuclear Science & Eng. Corp.

Repair Kit, Emergency.....Kit for repairing tanks, pipes, pumps, valves, flanges, air ducts, and miscellaneous machinery used by the oil, chemical, mining and other industries. See Bulletin.
453D Devcon Corp.

Research....."An Approach to Interpretive Research", 24 p. Bulletin S-1053 describes company's laboratory facilities and investigations that bridge the gap between theory and practical application.
453E Selas Corp. of America

Research.....32 p. booklet describes how company has used continuing research to achieve better automobile frames, line pipe, pressure vessels, welding electrodes, glass-lined water heaters.
453F A. O. Smith Corp.

Safety Equipment, Storage Tank..... Company offers Safety Bulletin Series on "Flammable Liquids, their characteristics, hazards and safe handling." Includes: conservation vents, tank openings, etc.
441b *Protectoseal Co.

Sampling Equipment.....New bulletin SSB-103 describes a highly accurate line of precision built splitters designed for sampling fine materials which segregate easily. Design, construction.
453G Carpco Mfg. Co.

Spectrochemical Analysis.....28 p. brochure describes basic fundamentals of spectrochemical analysis. Outlines methods, instruments, accessories. Includes bibliography. Request your copy.
453H Jarrell-Ash Co.

Technical Glassware.....New 234 p. catalog contains current prices on 11,130 items of laboratory and scientific glassware. Called Catalog TG-15, it contains special section on small apparatus.
453I Kontes Glass Co.

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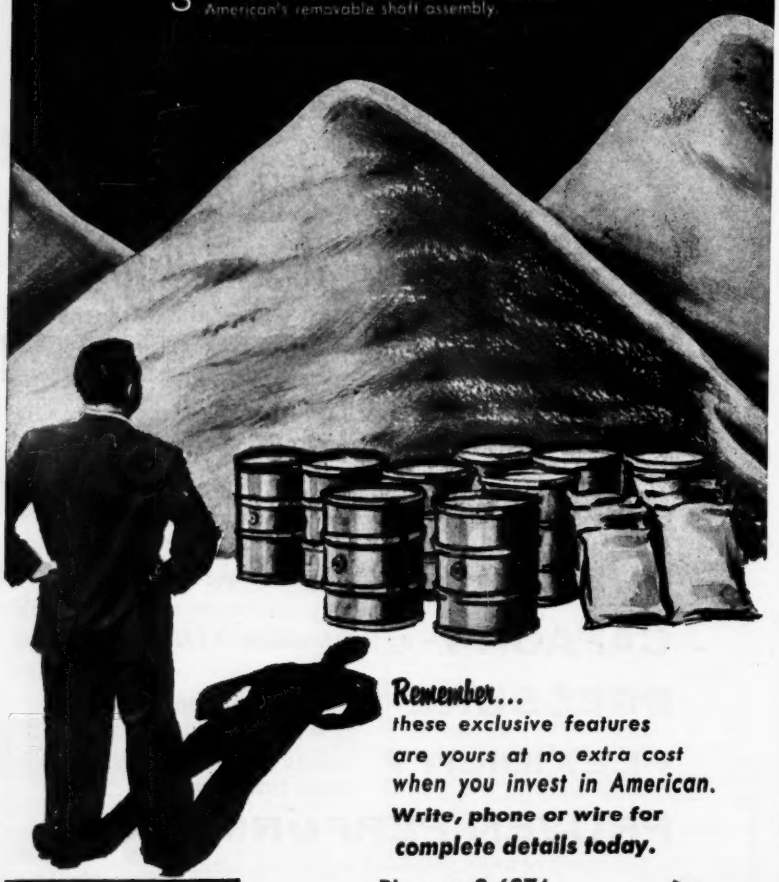

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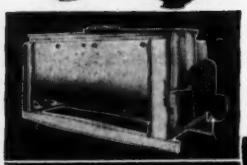

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PRODUCTS

Your complex index to chemicals, materials, equipment and services, taken from this issue's advertisements, new products departments and "Guide to Technical Literature."

Products listed feature code numbers which show the page on which they appear, L (left), R (right), T (top), B (bottom) indicate ad location; A, B, C, etc. and a, b, c, etc. identify specific product items on an editorial page or in an ad.

You can get information on any listings by circling its key number on the Reader Service Postcard (see inside back cover. Replies will come direct from the companies manufacturing the products.

Chemicals

Acid, levulinic....217
Acids, fatty....L460a
Acrylic emulsions....420A
Aluminum isopropoxide....420B
Anti-flame agent TD1223....362Bd
Antistatic agents, TD1221....362Bb
Boron-10....176A
Boron nitride, cubic....184A
Butyl rubber....420C
Catalysts....112
Cellulose, wood....420
Chemicals
  Aluminum....85
  Industrial....293a
  Organic....179
Chlorides, phosphorus....364c
Chlorine....147
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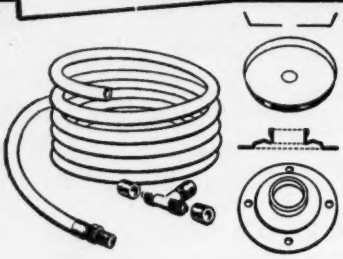

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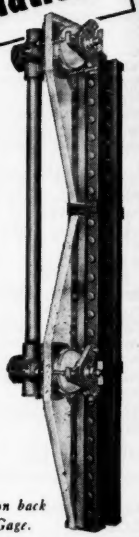

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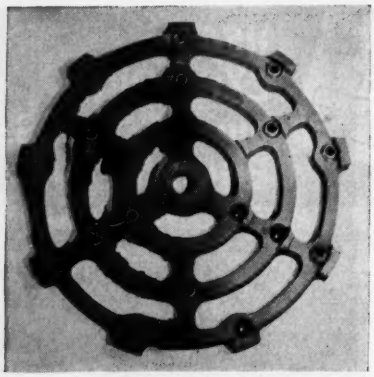

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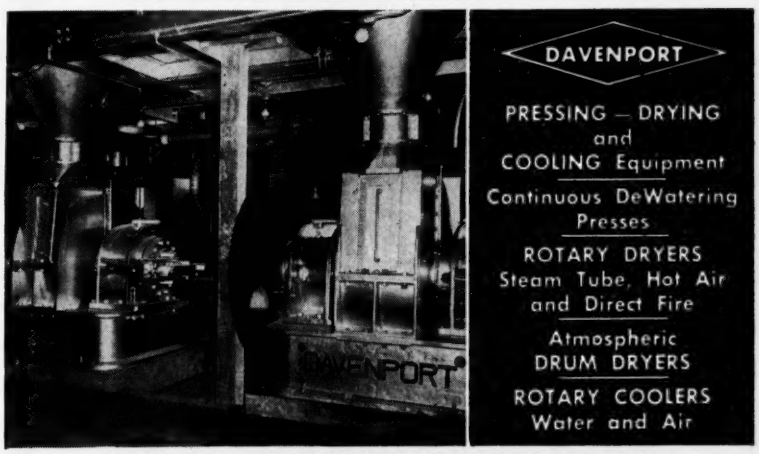

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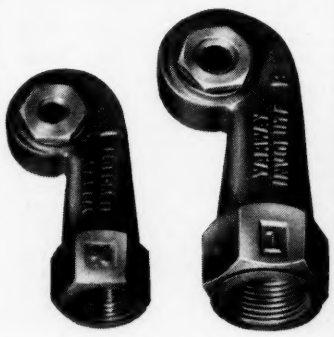
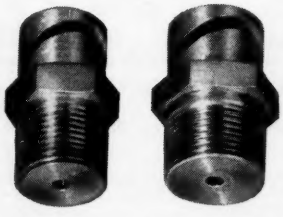
GET MORE OUT OF YOUR SPRAYING EQUIPMENT WITH LESS POWER

For spraying, washing, rinsing and cooling, Yarway Spray Nozzles will improve the efficiency of your spray equipment.

There are no internal vanes or other restrictions to clog or hinder the flow.



Cast bronze Involute-type
(Bar stock also available)



Bar stock Fan-spray-type

Yarway Spray Nozzles are available in two types—the Yarway Involute producing fine hollow cone spray with minimum energy loss, and the Yarway Fan-spray for flat fan-shaped spray with time-saving slicing action for cleaning.

Ask for a free copy—Bulletin N-618.

YARNALL-WARING COMPANY
137 Mermaid Avenue
Philadelphia 18, Pa.

YARWAY | *spray nozzles*

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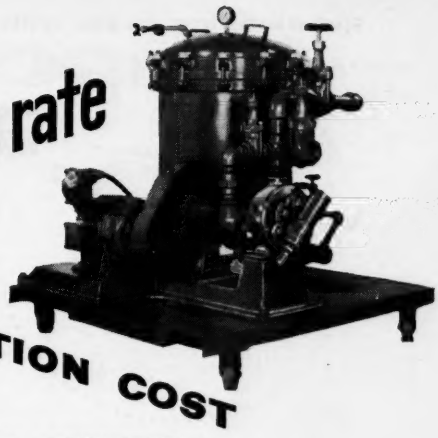
• It is your complete guide to chemicals, materials, equipment and services, taken from this issue's advertisements, new products departments and technical literature.

• Products listed feature code numbers which show the page on which they appear, L (left), R (right), T (top), B (bottom) indicate ad location; A, B, C, etc. and a, b, c, etc. identify specific product items on an editorial page or in an ad.

• You can get more information on any listing by circling its key number on the Reader Service Postcard (see inside back cover). Replies will come direct from the companies manufacturing the products.



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LOW OPERATION COST

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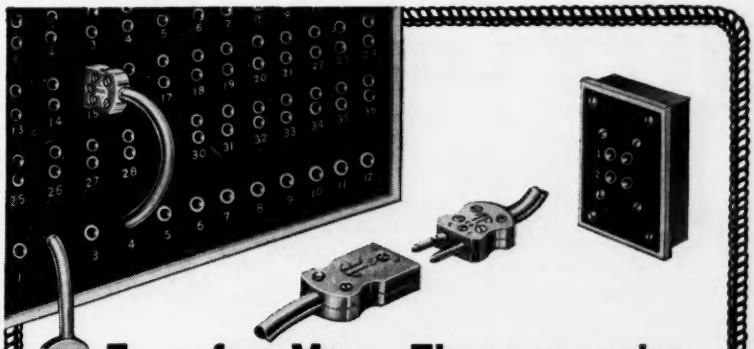
Vikings are adaptable to many pumping requirements—perhaps yours, too. *For information, write for Bulletin 57SC*

VIKING PUMP COMPANY Cedar Falls, Iowa, U.S.A.

In Canada, it's "ROTO-KING" pumps

THE ORIGINAL "*GEAR-WITHIN-A-GEAR*" ROTARY PUMP



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With T-E Quick-Coupling Connectors and Panels

Connector Panels T-E has one for your exact needs. These panels provide flexible, centralized control in transferring any number of thermocouples to indicating, multipoint recording and controlling pyrometers. Ideal for patch panel use, they are available in many compact shapes and sizes — with interchangeable plugs and jacks in I-C, C-C, and C-A. A panel for 48 thermocouples and 16 pyrometers measures only 13¼" x 7⅞". Polarity markings and screw-fastened connections make wiring easy.

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Write for Bulletin 23 E.

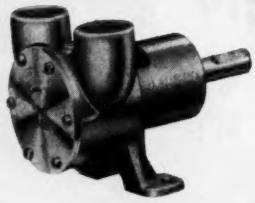
Thermo Electric Co., Inc.

SADDLE BROOK, NEW JERSEY

In Canada—THERMO ELECTRIC (Canada) Ltd., Brampton, Ont.

cut pumping costs with

JABSCO INDUSTRIAL PUMPS



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- SIMPLE, COMPACT, ONLY ONE MOVING PART
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- SELF-LUBRICATED
- TROUBLE-FREE OPERATION

Model 5330
Bronze Construction—
1" Port Size—Sealed
Ball Bearings

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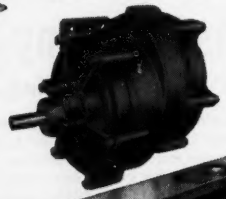
2031 Lincoln Street, Burbank, California

AJAX LO-VEYORS are cutting costs in Large Plants in Small Plants

AJAX Open Pan Lo-Veyor



AJAX-Shaler Shaker Drive

AJAX Closed Pan Lo-Veyor

AJAX Tubular Lo-Veyor

Plant layout men know that materials flow lines are never a static affair. That's why more and more AJAX LO-VEYORS are being used to give maximum flexibility to operations in large plants and small plants, indoors and outdoors.

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